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INVESTIGATION TO IMPROVE THE DEWATERING OF THE THICKNERS IN QCM IRON ORE PLANT

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MICROMEDIA

ABSTRACT

An iron ore company, Quebec Cartier Mining Co. at Mount Wright has difficulty in obtaining a well-defined interface in the thickener that treats the overflows of the recycle and fine tailings cyclones. Research work conducted in our laboratory on samples of thickener feed indicated the possibility of improving the dewatering results of this thickener by the use of anionic polyacrylamide flocculants. With flocculant addition of only 85 mg/t, the settling rate improves by 2-14 times and the amount of supernatant increases up to 30%.

Key Words: Compression Zone, Turbidity, Flocculant, Overflow, Underflow

RÉSUMÉ

L'usine de traitement de minerai de fer de la compagnie minière Québec Cartier, située au Mont Wright, a de la difficulté à obtenir une séparation solide/liquide adéquate à l'intérieur de l'épaissiseur qui est alimenté par les flux de surverses de recirculation et des rejets provenant des hydrocyclones. Les travaux de recherche, effectués dans nos laboratoires, sur des échantillons de l'alimentation de l'épaissiseur, prouvent qu'il est possible d'améliorer le rendement de la séparation solide/liquide à l'intérieur de l'épassiseur par l'ajout d'un floculant anionique, le polyacrylamide. Avec un ajout de floculant à une concentration aussi faible que 85 mg/t, le taux de sédimentation est de 2-14 fois supérieur au taux de sédimentation sans la présence de floculant, et de plus, la quantité liquide du surnageant augmente en proportion jusqu'à 30% de plus que sa quantité initiale.

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INTRODUCTION

An iron ore company, Quebec Cartier Mining Co. (QCM) of Mount Wright, Quebec encountered difficulty in obtaining a well-defined interface between underflow and overflow in the thickener. An improvement wa also required in the clarity and quantity of the overflow water. The objective of this work was to try to solve the above problems by selecting a suitable flocculant for the thickener feed. The work was proposed as one of the elements of CANMET's Iron Ore Processing project.

Five drums of thickener feed samples were received from QCM. The samples had been collected from the overflows of the recycle and fine tailing cyclones. Each drum contained about 20 litres of pulp collected at various times and conditions of the circuit.

Long-chain polymers were tested. The work proceeded in 3 stages: first, to determine the charge type of the polymers (whether a cationic, and ionic or a non-anionic type); second, to find the optimum dosage in terms of settling rate, supernatant clarity, defined interface and solids concentration in the compression zone; third, to test the effect of pH, molecular weight of the polymer and the reaction time with the polymer.

EXPERIMENTATION AND DISCUSSION

Sample Preparation

Twelve bottles (all of about 1 litre size) were used to collect samples from each drum as received. By inserting each bottle as far as half the depth of the drum while the pulp was stirred vigorously to ensure homogeneous mixing, a representative sample was collected. Each bottle was marked with a number. Altogether there were 60 bottles, 12 from each drum.

The colour of samples ranged from light red to very dark red depending on which drum was sampled. Their specific gravity, pH reading, chemical assays and % solids are listed in Table 1 where the drum-to-drum differences are apparent. The mineralogical analysis of samples from Drums 1, 3 and 4 is included in Appendix A.

Quick Flocculant Screening Test

Selecting the best flocculant for a specific job is always a challenge. Since flocculants are expensive, they have to be chosen correctly for maximum effect. Therefore the first stage of this work was to do a preliminary screening to evaluate quickly the flocculant which gave the best clarity and settling rate. Cyanamid+ Superfloc flocculants, which include non-ionic, anionic and cationic types, were used throughout this work. In aqueous systems flocculants function primarily by a bridging mechanism. Hence they must be high in molecular weight for practical applications. Polyacrylamide is the most prominent member of the flocculant class. Its unique polymerization characteristics allow production of very high molecular weight polymers (5 -10*10**6). Four flocculants of three different charge types were chosen for this test:

1. Superfloc *plus N300
   (non-ionic, powder, polyacrylamide type)
2. Superfloc *plus A100
   (anionic, powder, polyacrylamide type)
3. Superfloc 355
   (highly cationic, liquid, polyamine type)
4. Superfloc *plus C436
   (cationic polymers, powder)

Solutions of flocculants with a concentration of 0.1% were prepared by mixing 100 mL of distilled water with 0.1 g (or mL) of flocculant using a magnetic stirrer. Depending on the type, it took 15 min. to 3 hours for the flocculant to be completely dissolved.

Samples for this test were taken from Drum 2. Using the same collection method described before, four samples were prepared one for each flocculant. Twenty-five mL of pulp was collected in a 50 mL size beaker and mixed, by inverting the beaker gently 3 times with 0.025 mL of the diluted floccvlant. This gave a dosage of 1 ppm. Mixing should be thorough enough to ensure efficient use of the flocculant but not too vigorous since floc degradation can occur.

+ Mention of these particular products does not imply that they are endorsed by CANMET

Within 5 minutes, different degrees of clarity were observed: flocculants A100 and C436 generated better clarity followed by N300 and 355. Solids in the pulp that was treated with 355 settled slower than those treated with the other three flocculants. Also it was observed that the reddish colour of the pulp only faded slightly after an hour and a half. Thus, Superfloc 355, a highly cationic polyamine type flocculant suitable one for this study and therefore was ruled out from the remaining tests.

Effects and Interactions of Flocculants

Searching for maximum information with a minimum effort, a 2^3 factorial design was employed to study the effects and interactions of the remaining three polymer types (A100 for anionic, C436 for cationic and N300 for non-ionic). The laboratory graduated cylinder method was applied. The procedure was as follows:

1. Place the pulp in a 1 L graduated cylinder and mix thoroughly.
2. Add the diluted flocculant solution (0.1%) to the pulp to give the desired dosage. (e.g. 1cc of 0.1% flocculant solution in 1 L pulp gives dosage of 1 ppm).
3. Mix the flocculant solution into the pulp by inverting the cylinder gently three times.
4. Record the level of the solids-liquid interface as a function of time. (For easy illustration, volume of settled solids (ml) was used throughout this work)
5. Measure the turbidity of the supernatant at a fixed time after adding the flocculant.

The design matrix and laboratory results are given in Table 2. Three bottles (No. 7, 8 and 9) of Drum 2 were used in this test. Each variable (flocculant) was set at two levels (dosages): 0.1 ppm ('+' level) and 0 ppm ('-' level).

The columns in Table 2 represent:

1	A100
2	C436
3	N300 *
12	A100 + C436
13	N300 + A100
23	C436 + N300
	A100 + C436 + N300
123	N300 + A100 + C436
	C436 + N300 + A100

Columns 12, 13, 23 and 123 were used in order to estimate the effect of interactions of the polymer combinations on treatment efficiency. Statistical evaluation was done by using a computer program FADESN (1) written by the author. If tests 8, 9 and 10 were considered as replicate measurements, the variance of experimental error could be derived and used in the calculation of F-ratio. (The different responses observed among them could also be caused by the order of adding the flocculants.)

Clarity in these tests was measured with a Turbidimeter (Model DRT-1000, HF Instrument Ltd. in terms of Nephelometric turbidity unit, NTU)*. It was measured approximately 30 min. after adding the flocculant. Later experiments showed that as time elapsed, clarity improved gradually until finally becoming stable approximately 24 hours after flocculation. In fact, surface charges usually generate a repulsive force between particles, tending to keep them apart. For the large particles, gravitational forces are dominant and make them unstable with respect to suspension; for individual particles of colloidal dimensions the electrostatic and microhydrodynamic forces dominate and make their suspensions relatively stable. After flocculation, these colloidal particles aggregate into large entities for which gravitational forces dominate and therefore suspension stability is lost.

Some fine particles could be observed falling rapidly to the bottom of the cylinder while others still floated in the supernatant. This process continued for many hours although the majority of the solids appeared to

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* The plus sign also represents the order of adding the flocculants

have settled down within the first few seconds to 2 minutes depending on the dosage and the polymer type used. The interface was difficult to define during the settling process when no flocculant was used. With increasing dosage, the settling rate increased rapidly and the interface became better defined.

The computer result (see Appendix B) shows that by using supernatant clarity for evaluation, the most significant effect is generated by interaction 123 followed by interaction 12. However, by using volume settling rate for evaluatic , none of the flocculants nor their interactions passes the F-test at 95% confidence level. This means that none of the effects is significant. From Table 2, one can easily see that better volume settling rates are produced by using two or three flocculants. This observation can either be interpreted as due to the effect of the interactions or merely due to the higher dosage resulting from the combination flocculants (e.g. 0.2 ppm for combining two flocculants and 0.3 ppm for three). More experiments were later carried out to investigate.

As a conclusion, factorial design was not considered to be the best and most reliable method to evaluate the type of the flocculants suitable for this application. However, we can say, with some degree of confidence, that A100 and C436 are the better choices since both of them were used in the interactions that generated significant effects.

Charge and Dosage Effects

It was decided to pursue the conventional "one variable at a time" strategy and investigations were concentrated on cationic (C436) and anionic (A100) polymers.

The dosage levels were set at 0.1, 0.2, 0.4, 1, 2 and 4 ppm and samples from Drum 5 were used (with pH 5.57, the lowest among the five drums). The results from each polymer type are presented in Figures 1 and 2 respectively. For better illustration, 1 and 2 ppm are omitted from the figures. By stage addition only two samples were used for each polymer type: the first sample was started with 0.1 ppm, then increased to 0.2 ppm, 0.4 ppm and ended with 1 ppm by adding the required amount each time; whereas the second sample was started with 1 ppm, then increased to 2 ppm and ended with 4 ppm. According to Pearse (2), stage addition of flocculant increases

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* Interchangable with Formazin turbidity unit (FTU) and Jackson turbidity unit (JTU)

the chance of interparticle collision and flocculation before the polymer chains become strongly adsorbed along their lengths. However, in this work no significant improvement was observed. The anionic polymer gives a much better settling rate than the cationic polymer. In general, settling rate increases with dosage except in Figure 2 where it became worse at 4 ppm.

The bottles prepared for the test did not contain exactly 1 L of pulp (between 1000 to 1030 ml). Therefore the dosage level for pulp with more than 1 L may be diluted by up to 3%. For better illustration, the initial height of the pulp in all the settling curves was normalized to 1000 mL. This produced different final interface heights as a result.

Figure 3 shows the combination of the two polymers by adding different amount of cationic polymer into 1 ppm of anionic polymer. It shows that by combining the two flocculants at above 1 ppm does not provide any improvement in the settling rate.

Clarity of the supernatant measured at various dosages is shown in Figure 4 and it was measured within a short period of time (approximately one hour) after adding the flocculant. As can be seen, clarity improved with the dosage. The anionic polymer gives poorer clarity at 0.1 ppm but better clarity between 0.2 to 1.5 ppm. The cationic polymer and the combination of the two produce better performance above 2 ppm.

The solids concentration in the compression zone was calculated in each test (Table 3). Both polymers give best values at 0.1 ppm which means more large, loose, fragile flocs are collapsed under compression to produce high 'underflow' densities and at the same time more overflow water.

Similar tests were also performed by using samples from Drum 4 with anionic polymer (see Figure 5). The only difference was that, instead of increasing the dosage in the same sample by stage addition, fresh sample was used for each dosage level.

The relationship between the settling rate and the dosage is shown in Figure 6. It must be noted that when more than 1 ppm of anionic polymer was used, the settling of the solids was so fast that it only took a few seconds for the solids to reach the compression zone. It was therefore difficult for the human eye to record both the time and the position during the settling process with accuracy. Under such circumstances, two persons were needed to perform the test, with one recording the time while the other marked the position.

Summarizing the results, it is apparent that the anionic polymer is superior to the cationic polymer in terms of the settleability of the solids and the final solids concentration. In the case of the cationic polymer, the improvement of the settling rate ends when the dosage reaches 2 ppm. However, the latter produces slightly better clarity with the dosage above 2 ppm. To better compare these two flocculant types, a summary is presented in Table 4.

Molecular Weight Effect

The effect of molecular weight was studied by comparing the settling rate and turbidity of the two flocculants A100 and A130. The latter is also an anionic polyacrylamide type polymer except with a higher anionic charge and molecular weight. No significant difference was observed (Figures 7 and 8). Figure 8 shows that without the flocculant, the turbidity of the supernatant, measured 10 minutes after the settling, is very poor at 620 NTU. However, the clarity improves rapidly and reaches a low level at 15 NTU 24 hours after settling (compared to 10 and 8 NTU with additions of 0.1 ppm A100 and 0.1 ppm A130 respectively). As mentioned before, the longer the time after settling, the better is the clarity.

pH Effect

Samples from Drum 3 were used in this test and the pH was adjusted through the range 2 to 12. Adjustment of the pH of the pulp was accomplished by mixing 0.2N HCL or 0.2N NaOH with the sample (Table 5). Much more reagent was required (80 cc) in order to produce a pH of 2 or 11. The sample thus produced was unstable and tended to neutralize slightly with time. In fact, it was noticed that the pH of the samples had been changed a little in a period of 2 months (e.g. Drum 4 from 6.14 to 5.43 and Drum 3 from 6.73 to 7.53).

The results of this test are presented in Figures 9 and 10. As can be seen, the clarity of the supernatant measured 24 hours after settling becomes poorer as the pH increases (from 5 NTU at pH 2 to 26 NTU at pH 12) and also when a flocculant of 0.1 ppm is used (from 13 NTU at pH 2 to 38 NTU at pH 12). It was observed during the tests that the flocculant had changed the color of the supernatant to a very light yellow. Figure 10 shows that

the settling rate improves when a flocculant is used and also increases parabolically at extremes of pH.

Effect of Reaction Time After Adding Flocculant

Practically, long conditioning time is unlikely to be applied in the plant. This test is mainly for scientific point of interest. A sample from Drum 2 was treated with 0.2 ppm of A100 polymer. By inverting the cylinder once, the level of the interface was recorded at different times (5 min., 1 hour, 2 hours, 5 hours and 18 hours) after adding the flocculant. The settling curves are shown in Figure 11 where we can see that the settling rate became slower as the reaction time with the flocculant increases. This is because flocculants showed increased adsorption with time. Strongly adsorbed flocculants did not favour bridging due to lack of extended chains available for other particles to adhere to (3).

Summarized Results of All the Samples

Samples from all five drums were tested with 0.1 ppm of A100 and the results (Table 6) show that the flocculant is still suitable under various conditions encountered in the mill although the degree of improvement varies from one to the other. The settling rate improves by 2-14 times and the quantity of overflow water increases up to 30% in Drum 4 (although there was no change in Drum 2); whereas supernatant clarity remains low in the range of 10-53 NTU i.e. 77-97% transmittance or 10-22 NTU i.e. 92-97% transmittance if excluding Drum 1. With or without flocculant addition, the turbidity of Drum 1 is almost 3 times that in the other drums. It appeared to contain higher levels of fine particles requiring a much longer settling period for clarification.

The relationship between NTU and percent transmittance is shown in Figure 12. The latter was measured by using a spectrophotometer (Baush & Lomb Spectronic 20) at a wavelength of 540 nm. Solutions of Formazin standard suspensions were used as standards for calibration. Total suspended solids were not determined in this study.

CONCLUSIONS

Summarizing the results of all the tests, it has been shown that flocculants of high molecular weight, long-chain, polyacrylamide-type polymers perform well in this application. Anionic polymers are more cost-effective than their cationic counterparts because of lower cost and higher molecular weight. (The price quoted by Cyanamid at the time of writing is $3.75/kg for Superfloc A100 series and N300 series; $4.18/kg for C400 series.) They are capable of forming large, rapid-settling and good-compacting flocs.

With anionic flocculant additions of as low as 0.1 ppm or 85 mg/t, the settling rates were significantly enhanced by 2-14 times and the amount of overflow water was increased by up to 30%. However it should be noted that in this study, flocculant additions did not improve the supernatant quality. Further studies should be done to include pretreatments by coagulants (such as alum, ferric chloride, lime, etc.) and the complete process should be tested at a pilot-plant scale.

ACKNOWLEDGEMENTS

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Table 1 - Some characteristics of the samples received

Drum No.	pH	Solids specific gravity	% solids	% Fe	% SiO_2
1	6.44	3.15	2.1	21.41	59.56
2	6.43	3.22	2.7	24.93	57.98
3	6.73	3.02	4.7	17.66	63.59
4	6.14	2.91	5.4	12.76	71.06
5	5.57	3.05	4.3	17.15	66.23

Table 2 - Design matrix 2^3 with test results using samples in drum 2

	Column No.								
Test No.	1	2	12	3	13	23	123	Vol. settling rate (mL/sec)	Turbidity* (NTU)
1	-	-	+	-	+	+	-	1.2	182
2	+	-	-	-	-	+	+	13.8	480
3	-	+	-	-	+	-	+	11.3	370
4	+	+	+	-	-	-	-	32.5	180
5	-	-	+	+	-	-	+	12.6	420
6	+	-	-	+	+	-	-	33.3	263
7	-	+	-	+	-	+	-	20.5	290
8)								(33.2	155
9)	+	+	+	+	+	+	+	(43.3	150
10)								(32.8	215

* measured 30 minutes after adding the flocculant

Table 3 - The effect of flocculants on % solids in compression zone

Flocculant dosage	% Solids
nil	44
C436 0.1 ppm	46.8
0.2	45.0
0.4	37.5
1.0	42.3
2.0	43.6
4.0	41
A100 0.1 ppm	47.5
0.2	45.0
0.4	42.9
1.0	42.0
2.0	40.1
4.0	41.2
1 ppm A100 + 1 ppm C436	41.9
1 ppm A100 + 2 ppm C436	40.0
1 ppm A100 + 4 ppm C436	39.3

Table 4 - Comparison of test results with anionic and cationic polymers

Flocculant		Settling rate m/h	Supernatant clarity NTU*	% solids in compressive zone
Type	Dosage, ppm			
Anionic (A100)	0.1	14.0	182	47.5
	0.2	27.7	110	45.0
	0.4	48.0	57	42.9
	1.0	95.8	55	42.0
	2.0	189.0	56	40.1
	4.0	272.0	51	40.2
Cationic (C436)	0.1	8.5	144	46.8
	0.2	14.4	115	45.0
	0.4	31.5	96	37.5
	1.0	44.1	74	42.3
	2.0	63.0	34	43.6
	4.0	75.6	30	41.0

*measured one hour after adding the flocculant (for better clarity, 24 hour settling period is required)

Table 5 - Adjustment of the pH

Sample	Addition of pH modifier			
	Reagent	Amount mL	Before	After
Drum 3 Bottle 1	HCl	80	7.5	2.03
Bottle 7	HCl	5.8	7.4	3.98
Bottle 3	NaOH	5.8	7.5	10.03
Bottle 4	NaOH	80	7.4	11.69

Table 6 - Results before and after adding 0.1 ppm Superfloc A100

Drum no.	Settling rate (m/h)		Supernatant clarity (NTU)**		% Solids in C.Z.***	
	Before	After	Before	After	Before	After
1	2.1	15.1	47 (79)*	53 (77)	39	43
2	1.5	21.4	-	-	47	47
3	2.1	5.0	19 (94)	22 (92)	43	44
4	1.9	13.5	12 (96)	17 (95)	38	49
5	1.5	9.5	15 (95)	10 (97)	44	48

* values in terms of % transmittance
** measured 24 hours after adding the flocculant
*** compression zone

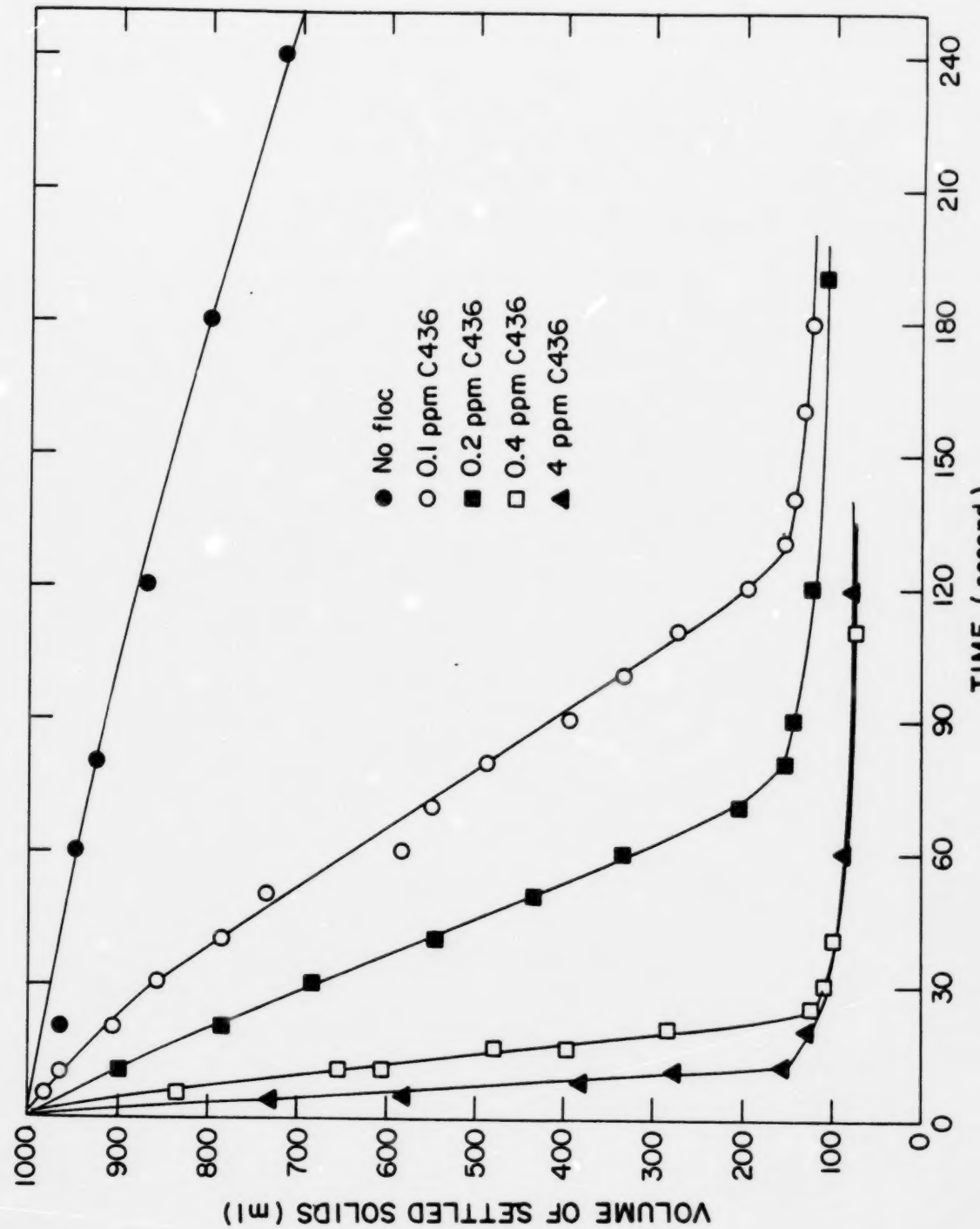

Fig. 1 - Settling tests with catonic polymer (samples from drum 5)

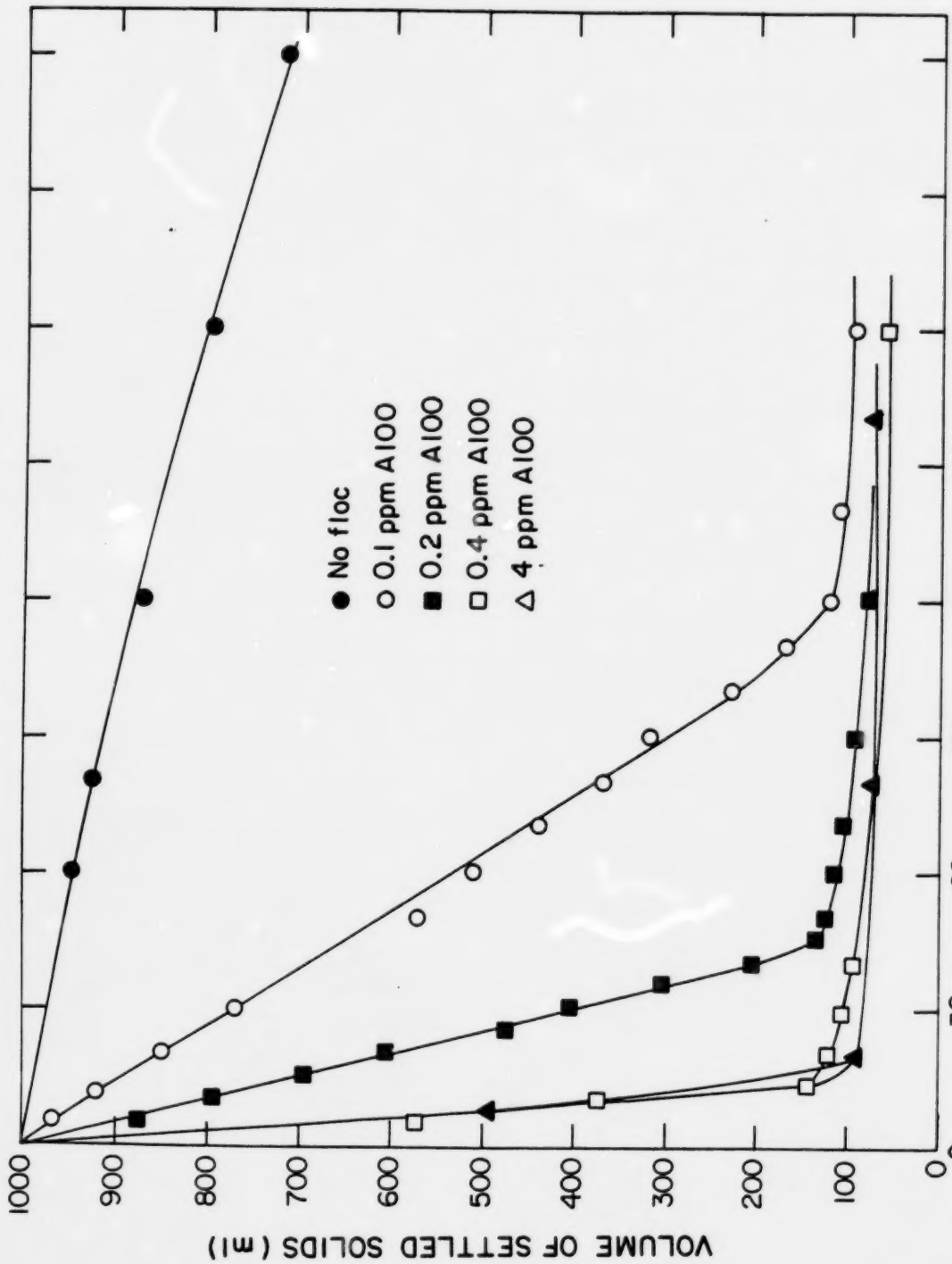

Fig. 2 - Settling tests with anionic polymer (samples from drum 5)

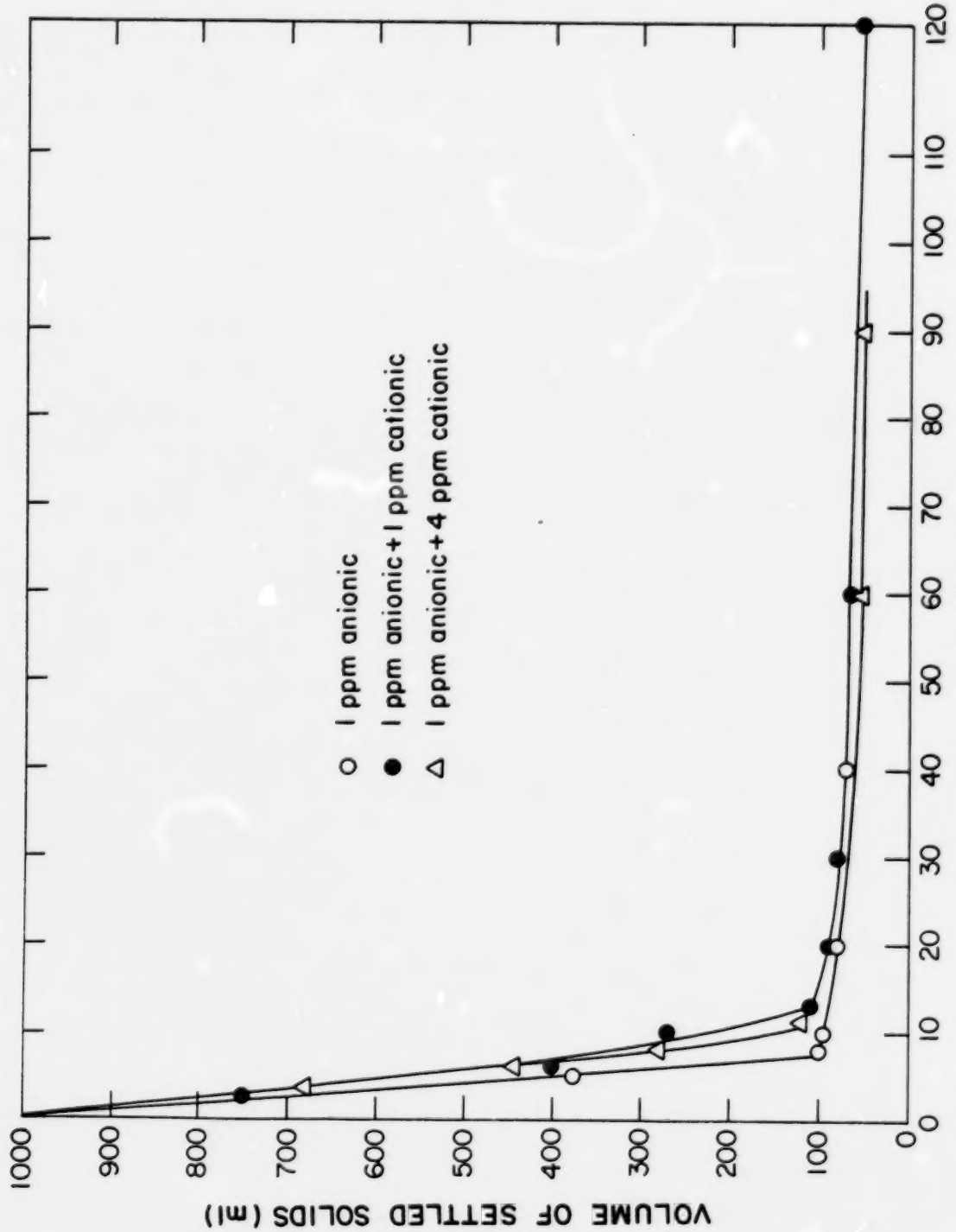

Fig. 3 - Settling tests with combinations of polymers (samples from drum 5)

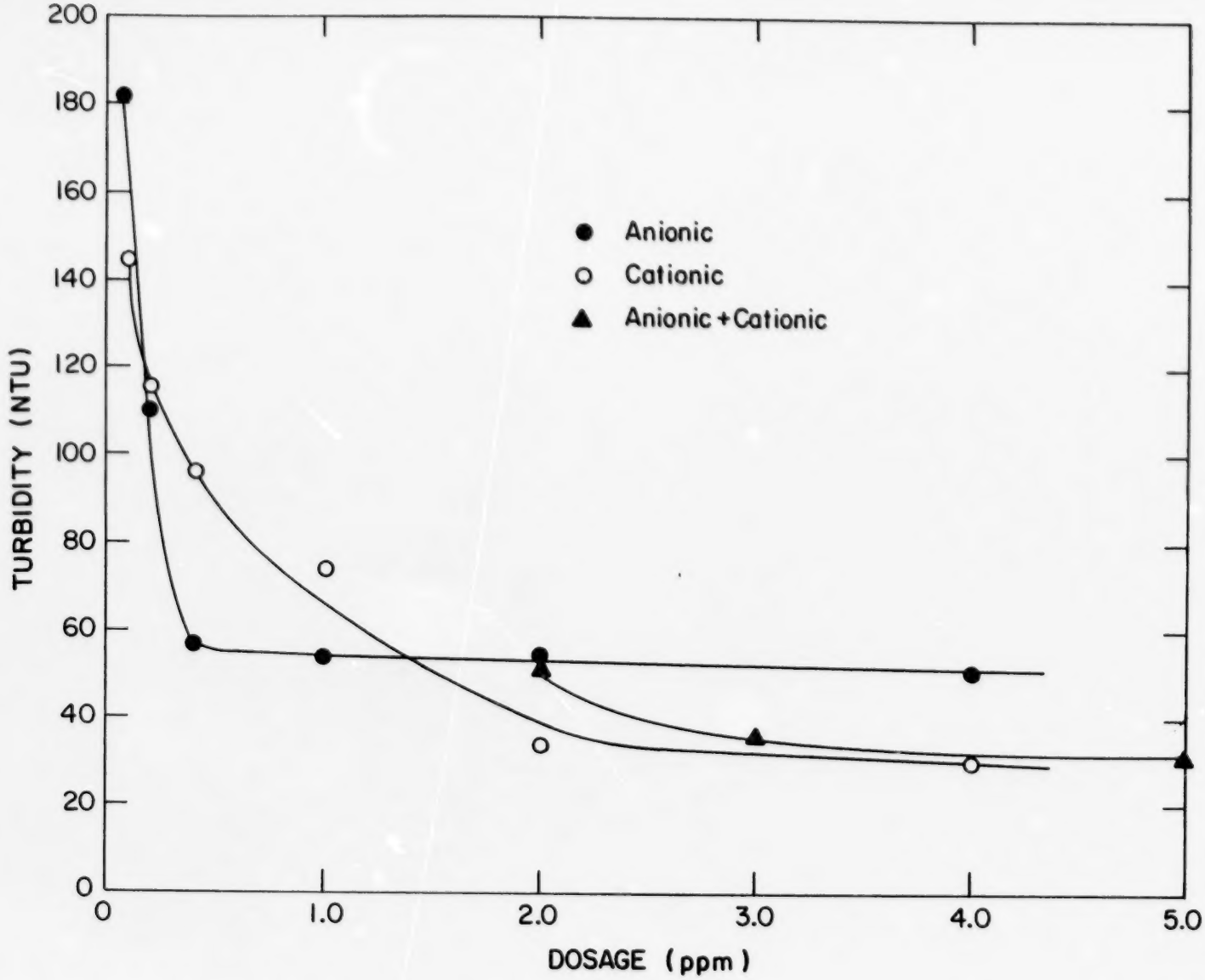

Fig. 4 - Turbidity results with different polymers (measured at one hour after adding flocculant, samples from drum 5)

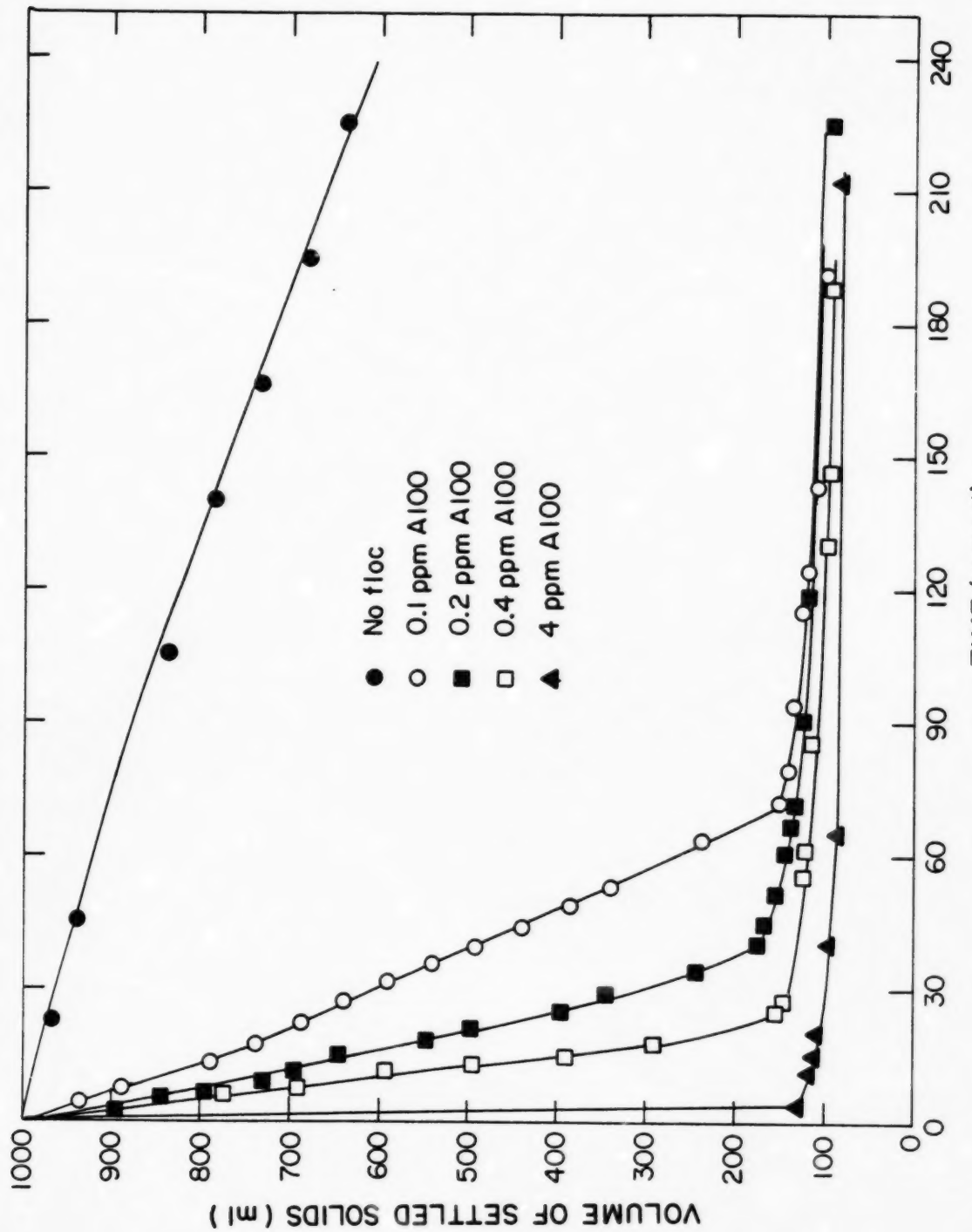

Fig. 5 - Settling tests with anionic polymer (samples from drum 4)

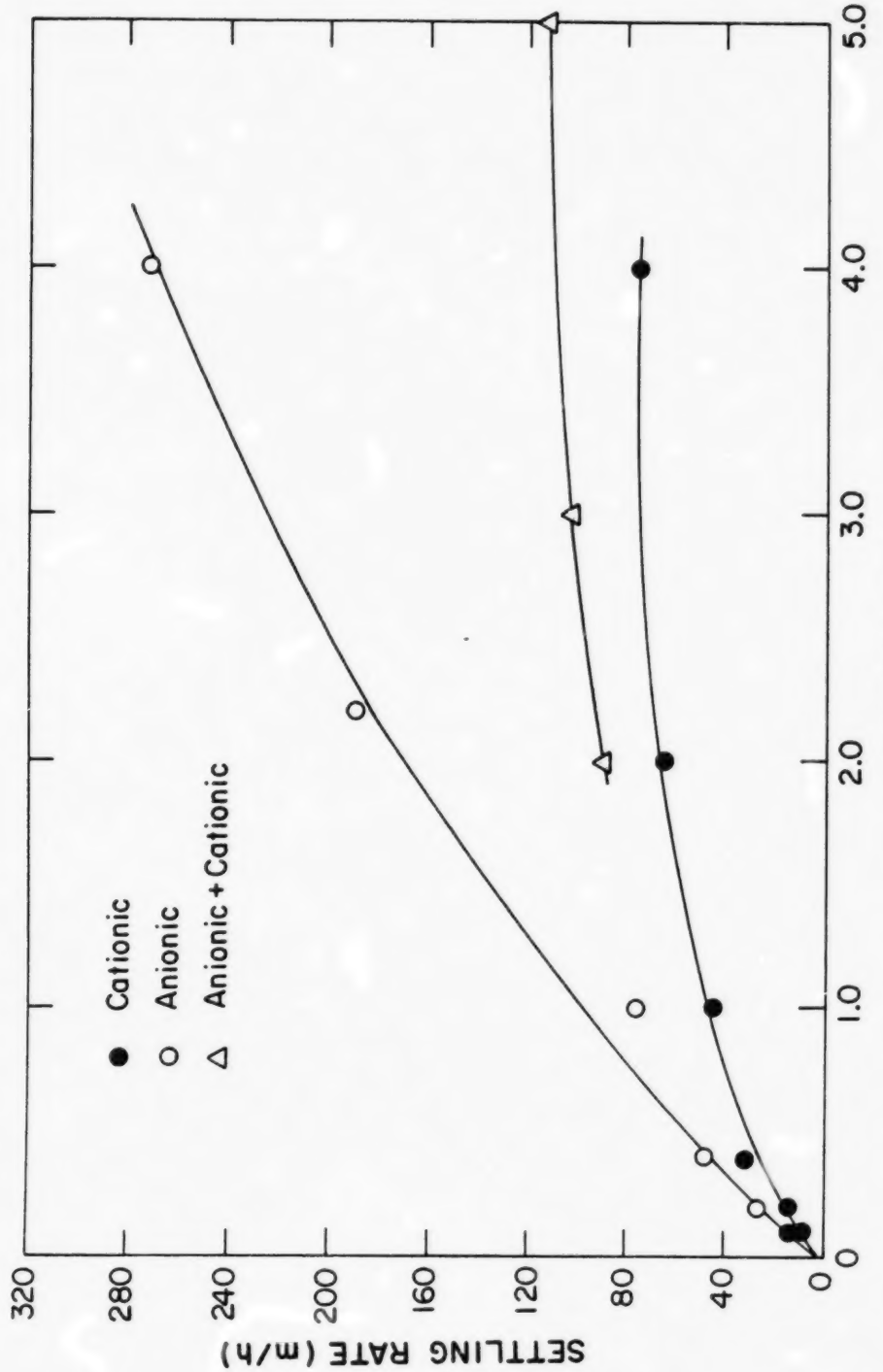

Fig. 6 - Settling rate vs dosage of different polymers

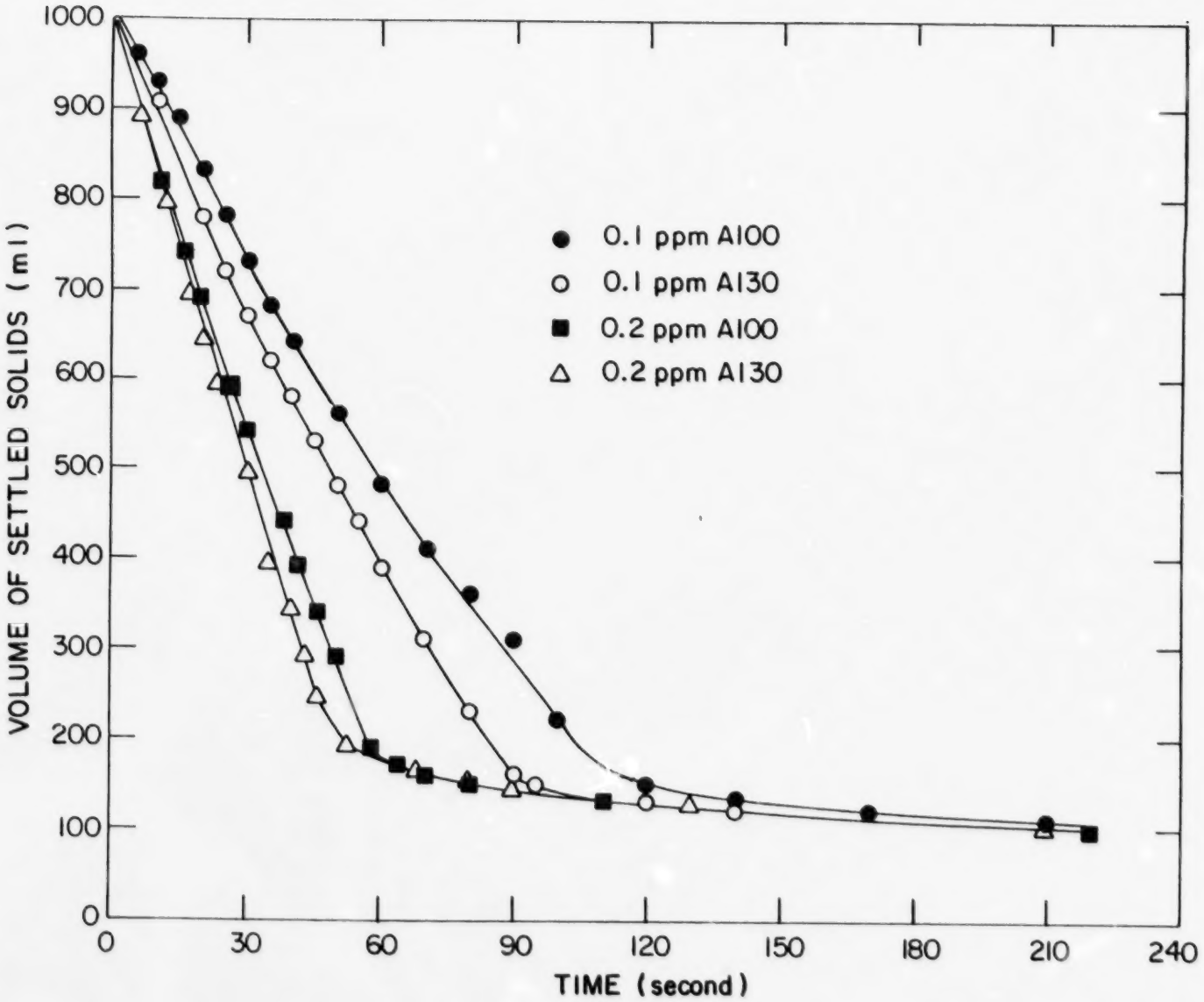

Fig. 7 - Settling tests with different molecular weights of anionic polymers (samples from drum 5)

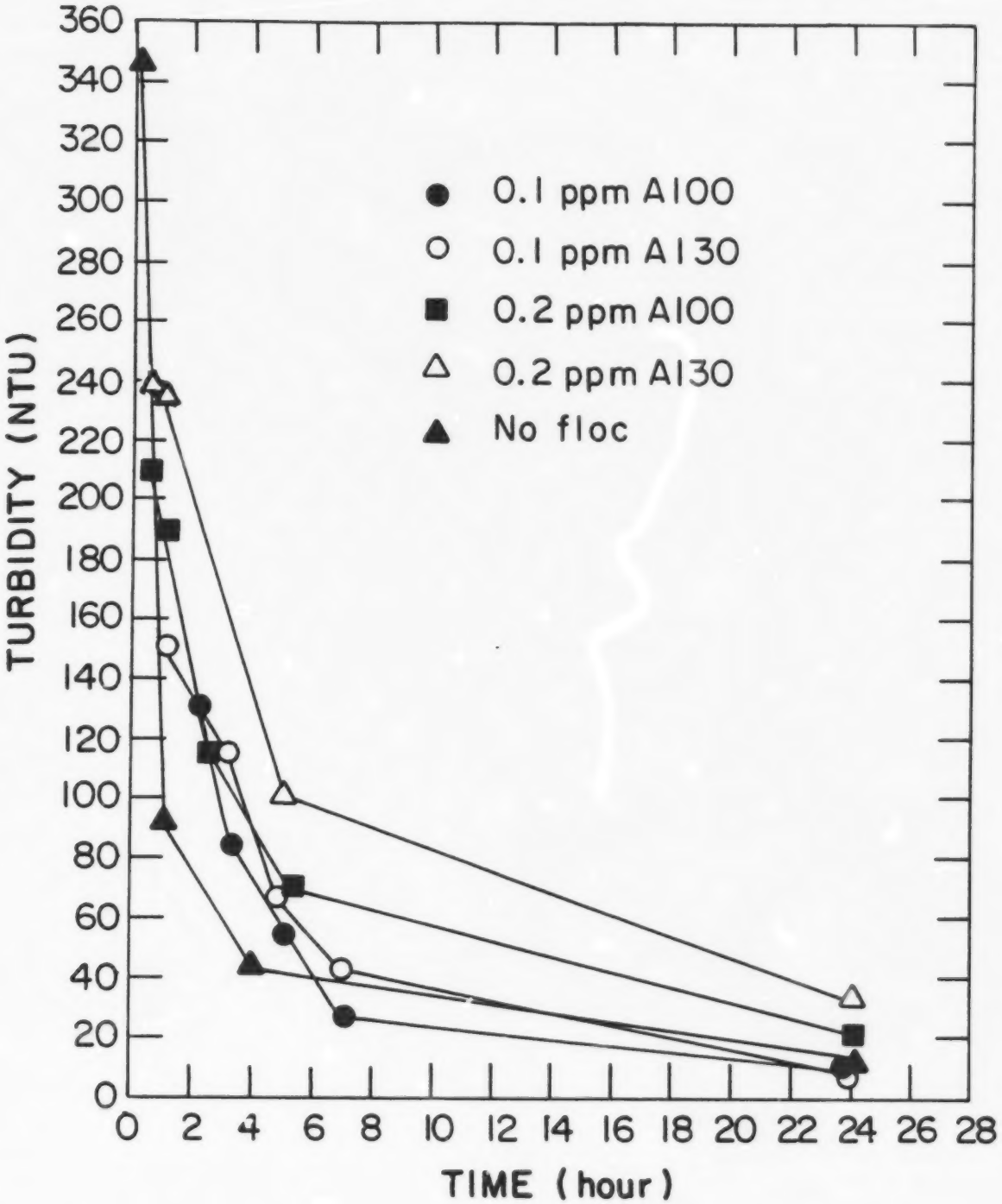

Fig. 8 - Turbidity results with different molecular weights of anionic polymers samples from drum 5)

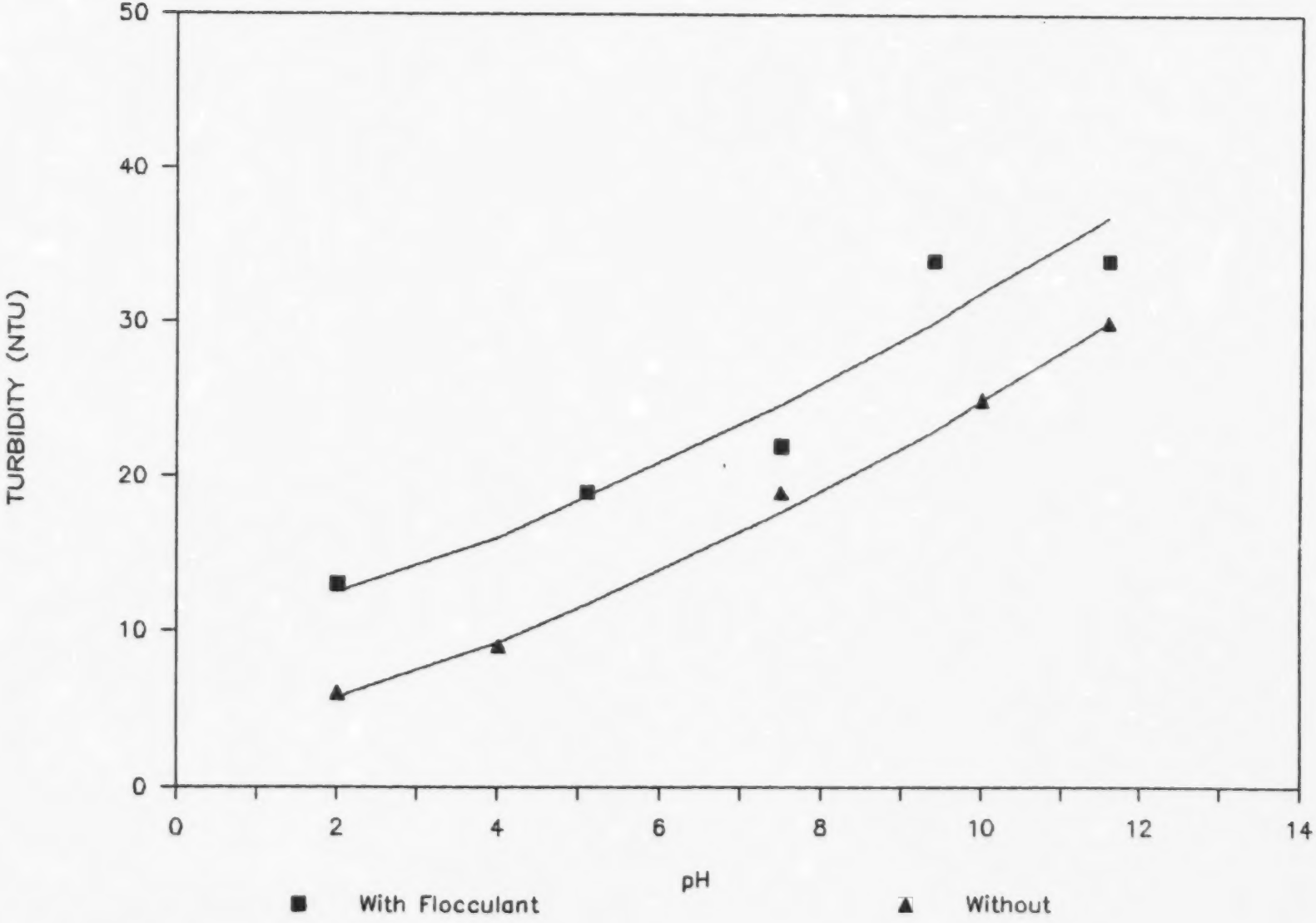

Fig. 9 - Turbidity at different pH (measured 24 hours after adding flocculant, samples from drum 3)

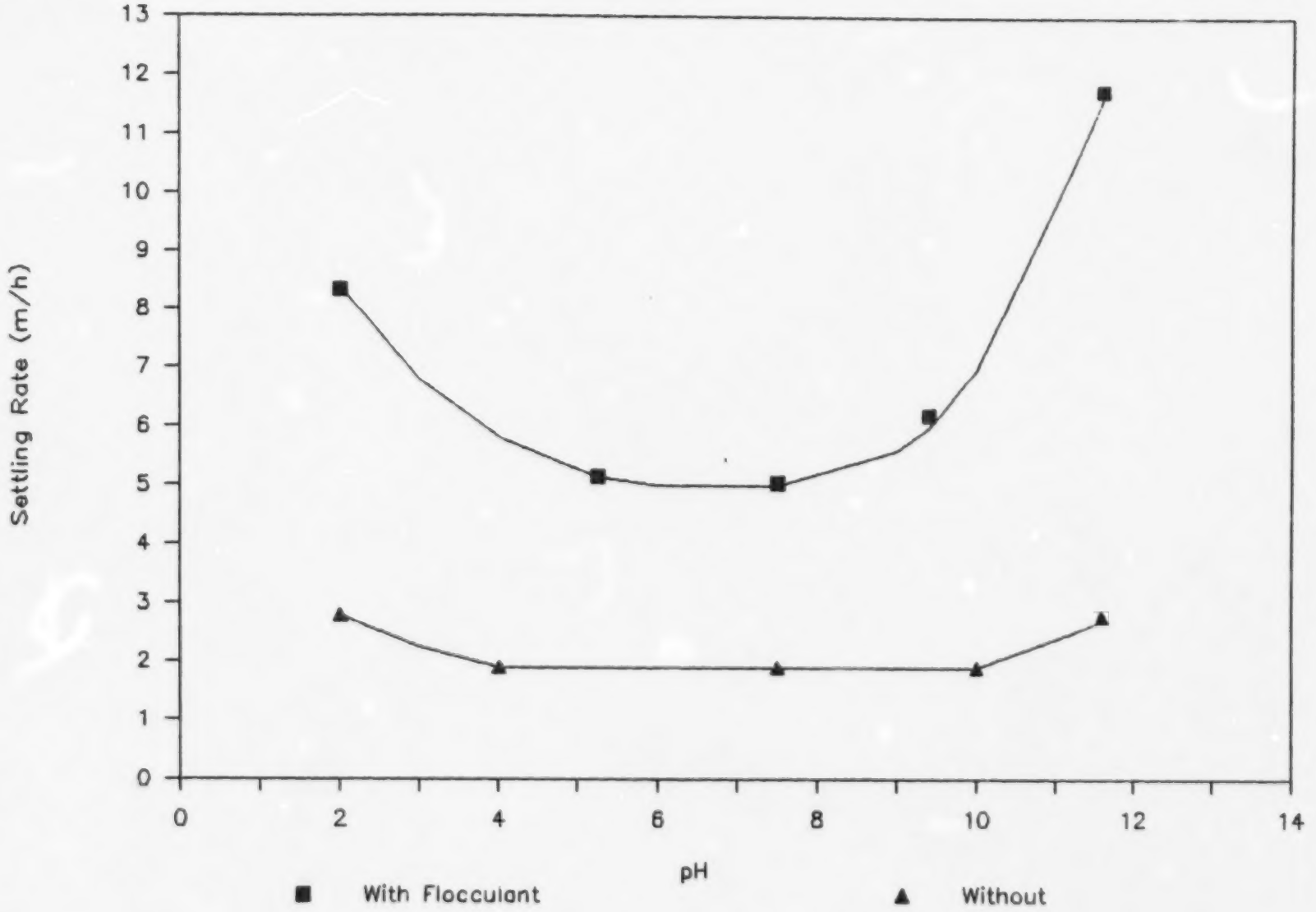

Fig. 10 - Settling rate at different pH (samples from drum 3)

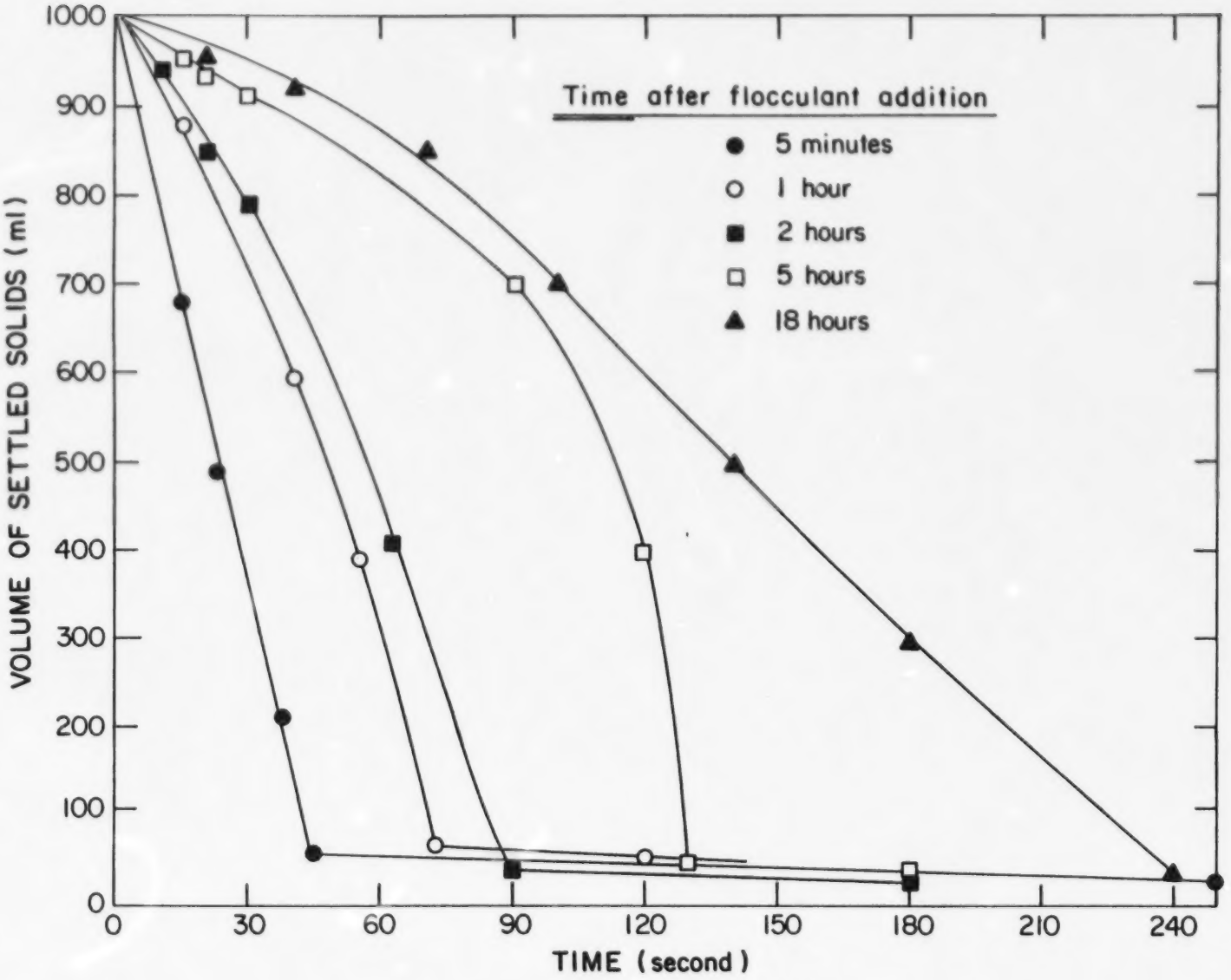

Fig. 11 - Settling tests with different reaction times (samples from drum 2)

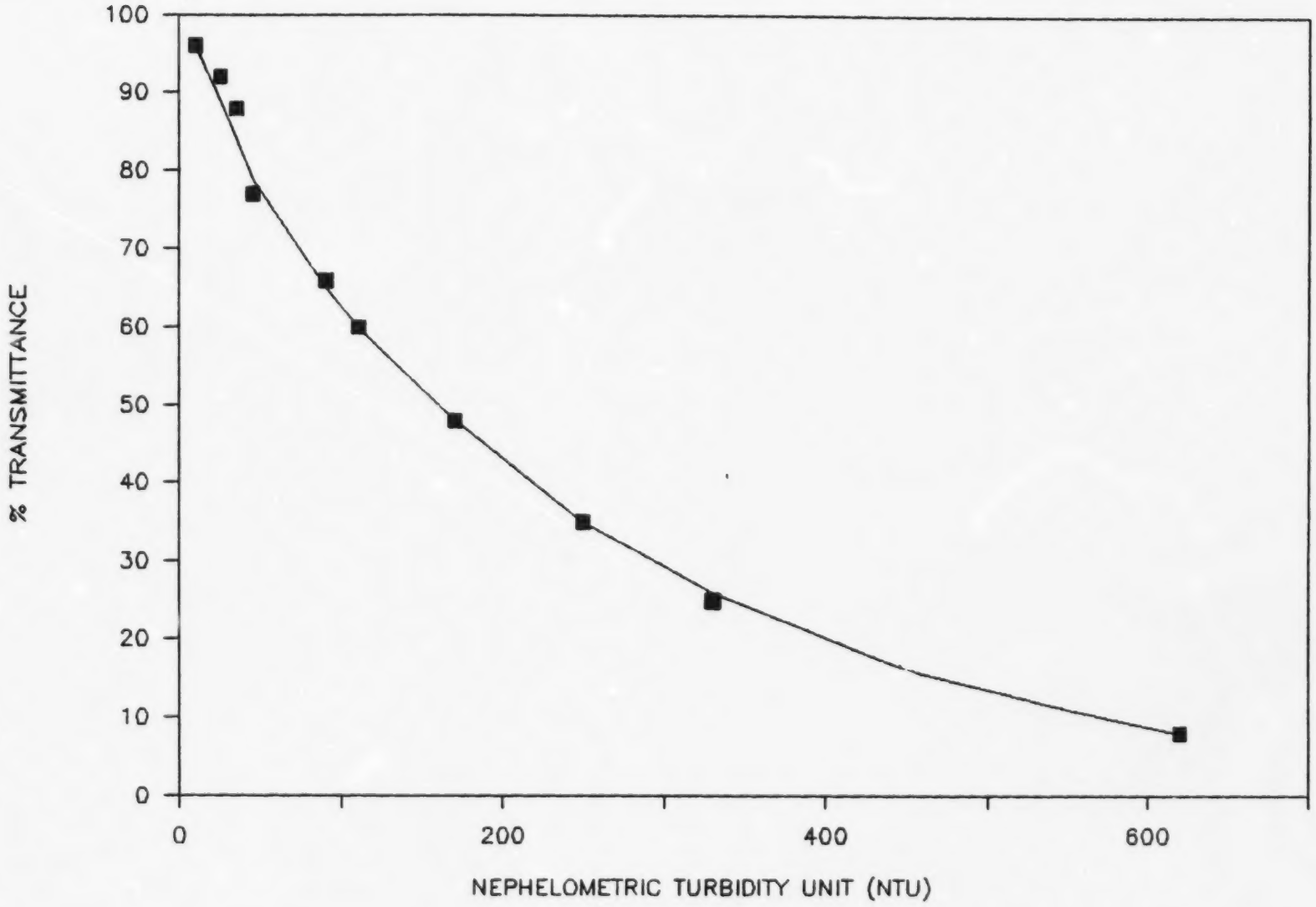

Fig. 12 - Nephelometric turbidity unit (NUT) vs % transmittance

APPENDIX A

REPORT OF MINERALOGICAL ANALYSIS

MINERAL SCIENCES LABORATORIES

PROCESS MINERALOGY SECTION

SECTION REPORT M-3703

TITLE: Image Analysis Study of Samples from QCM

INVESTIGATOR: W. Petruk

PROJECT: 301302

SAMPLE: Three powdered samples labelled D1-B5, D3-B8 and D4-B5 were received from J. Leung in November, 1986.

PURPOSE: Identify minerals and determine size distribution of Fe minerals.

METHOD OF INVESTIGATION: Polished sections were prepared from the sample and analysed with the image analyser.

RESULTS: The minerals were identified with the energy dispersive X-ray analyses (EDXA) and mineral quantities were determined with the MP-SEM-IPS image analysis system (Table 1).

The liberation characteristics of the hematite and goethite were determined by measuring the percentages of each mineral that occurs in particles which contain 0-9.9, 9.9-19.9, 19.9-29.9, 29.9-39.9, 39.9-49.9, 49.9-59.9, 59.9-69.9, 69.9-79.9, 79.9-89.9, 89.9-99.9, and 99.9-100.0% hematite and/or goethite. The 99.9-100% particles are free. The particles were also classified as containing 0-25, 25-50, 50-75 and 75-100% of the mineral of interest.

.../2

Signed _____ Approved _____ Date 9/2/87
INVESTIGATOR SECTION HEAD

Copies to: 1. J. Leung 2. W. Cameron 3. J. Wilson
ORIGINATOR PROJECT LEADER

4. MANAGER MPL 5. SECTION FILES

PLEASE NOTE : THIS REPORT NOT TO BE REFERENCED IN PUBLICATIONS

PLEASE ACKNOWLEDGE THIS WORK IN FINAL REPORT

Table 1. Mineral Quantities* in Sample.

Mineral	SP.GR	D1-B5	D3-B8	D4-B5
Quartz + feldspar	2.7	62.1	72.7	66.8
Amphibole + biotite	2.9	2.6	5.9	11.6
Apatite	3.1	0.4	0.3	0.04
Monazite	5.0	0.2	0.2	0.3
Hematite	5.0	32.0	19.0	19.3
Goethite	3.8	2.7	1.9	2.0
Total		100.0	100.0	100.0

*= Wt.%, calculated from vol.% by assuming specific gravity.

Table 2 shows the percentage of hematite, of goethite, and of (hematite-goethite) that are (1) free; (2) in particles which contain more than 89.9% hematite and/or goethite (i.e. 89.9-100% particles, includes free grains); and (3) in particles that contain more than 75% hematite, goethite and hematite-goethite.

The table also shows the percentage of hematite that occurs in hematite-goethite particles, and percentage of goethite that is in goethite-silicate particles. The percentage of goethite that is in hematite goethite particles was not analysed but can be calculated; i.e. 100%-%free goethite-%goethite in goethite-silicate particles=100-13.5-19.5=67% of goethite is in hematite-goethite particles.

Size distributions were determined for particles containing more than 89.9% hematite, more than 89.9% goethite, and more than 89.9% hematite plus goethite (Table 3).

Table 2. Liberation characteristics of Hematite, Goethite and Hematite-goethite.

	D1-B5	D3-B8	D4-B5
Hematite			
- % free	92.0	94.0	87.6
- % in +89.9% hematite particles	95.5	96.1	94.3
- % in +75% hematite particles	97.2	96.5	96.5
Hematite-goethite particles			
- % of hematite in hem-goethite particles	4.7	4.4	2.8
- % of hematite in +89.9% hem-goethite particles	2.5	3.5	2.2
- % of hematite in +75% hem-goethite particles	3.9	3.6	2.6
Hematite + Goethite			
- % free from silicates	17.8	16.8	11.4
- % in +89.9% hem+goethite particles	91.4	92.9	92.0
- % in +75% hem+goethite particles	96.6	95.7	96.1
Goethite			
- % free	13.5	13.8	13.7
- % in +89.9% goethite particles	72.0	74.7	88.0
- % in +75% goethite particles	85.4	81.3	90.1
Goethite-silicate particles			
- % of goethite in goethite-silicate particles	19.5	21.4	26.3
- % of goethite in +89.9% goethite-silicate particles	8.1	8.1	18.5
- % of goethite in +75% goethite-silicate particles	15.9	8.1	25.1

Table 3. Size distributions* of Hematite, Goethite and Hematite-goethite.

Size (µm)	Goethite +89.9%			Hematite +89.9%			Hematite & Goethite +89.9%		
	D4-B5	D3-B8	D1-B5	D4-B5	D3-B8	D1-B5	D4-B5	D3-B8	D1-B5
-3.25	.25	12.1	9.1	.1	5.7	7.7	0.1	6.2	7.7
-4.60	.34	23.4	22.3	.5	10.9	14.9	0.5	11.9	15.4
-6.50	1.29	32.2	39.5	2.7	19.0	28.2	2.1	20.4	29.1
-9.2	7.80	51.9	62.2	6.0	34.6	48.2	5.7	34.9	49.9
-13.0	18.72	78.3	75.9	11.0	51.8	72.5	11.2	54.1	73.7
-18.4	28.11	100.0	100.0	19.8	77.0	90.6	20.9	78.2	91.5
-26	50.34			33.5	92.1	98.7	35.6	92.3	98.9
-37	75.57			51.5	95.3	100.0	53.8	95.2	100.0
-52	91.03			79.0	100.0		79.9	100.0	
-74	100.0			90.2			91.2		
-104.0				100.0			100.0		

*% passing.

The classification of particles into 0-9.9, 9.9-19.9, 19.9-29.9, 29.9-39.9, 39.9-49.9, 49.9-59.9, 59.9-69.9, 69.9-79.9, 79.9-89.9, 89.9-99.9 and 99.9-100% hematite and/or goethite; and into 0-25, 25-50, 50-75, 75-100% hematite and/or goethite is shown on histograms in Figs. 1-6. The size distribution of the minerals occurring in the particles are also shown on histograms in Figs. 1-6. The heights of the bars in each histogram indicate the proportion of mineral occurring in each class or size range.

The classes of particles, and the sizes of the unliberated grains in the particles, were combined into three dimensional (3D) diagrams to show (1) the proportions of unliberated mineral occurring in each class of particle, and (2) the proportion of unliberated mineral occurring in each size range. The 3D diagrams are pictorial, but provide an immediate overview of the types of unliberated grains in the sample. The 3D diagrams may require some study to grasp the method of presentation, but once grasped they are extremely simple to read.

The following is a description of the method of presentation of the 3D diagram. It is recommended that the remainder of this paragraph be read while studying a 3D diagram:

1) The 3D diagram is composed of a base grid and vertical lines that extend from grid intersections.

2) The X-axis of the base grid is the particle classification (phase %) and the Y-axis (dia(mic)) the diameter of the unliberated grains in the particles. Each intersection on the X-axis corresponds to a different classification of the particles, and on the Y-axis to sizes of unliberated grains in the particles.

3) The point at the extreme left of the X-axis corresponds to the 0-9.9% particle class, and the point at the extreme right to the 99.9-100% particle class. Intermediate points and lines in the Y direction correspond to intermediate classes, i.e. 9.9-19.9, 19.9-29.9, 29.9-39.9 etc.

4) The points on the Y-axis of the grid correspond to the size ranges (in micrometres) 0-3.25, 3.25-4.60, 4.60-6.50, 6.50-9.19, 9.19-13.0, 13.0-18.4, 18.4-26.0, 26.0-36.8, 36.8-52, 52-73.5, 73.5-104, 104-147, 147-208, and +208, with the 0-3.25 size range represented by the front line of the grid, and the +208 size range represented by the back line.

5) The lengths of the vertical lines correspond to the relative proportions (in area %) of unliberated mineral grains that have the specific grain sizes and occur in the particular classes of particles which places them at a point on the base grid.

Data that were used to plot the particle classification histograms, the grain size distribution histograms, and the 3D diagrams were printed out by computer and are included in this report in case the reader wants numbers instead of pictorial presentations. The sample identity is shown at the top of each computer table, and a computer table number was generated for each category of unliberated grain. Computer Tables 2 and 8 refer to hematite + goethite associated with silicates; Tables 4 and 10 to hematite associated with silicates; Tables 6 and 12 to hematite associated with goethite; Tables 3 and 9 goethite associated with all minerals; and Tables 5 and 11 goethite associated with silicates.

The tables, like the 3D diagrams, may seem complicated at first glance, but are, in fact, extremely easy to read. The following notes are given to explain the designations in the tables and to teach the novice how to read them. It is recommended that the novice follow a table while reading this section.

(1) The numbers in the top line (10, 20, 30 etc) delimit the classification that was used, i.e. 0-9.9, 9.9-19.9, 19.9-29.9, 29.9-39.9, 39.9-49.9, 49.9-59.9, 59.9-69.9, 69.9-79.9, 79.9-89.9, 89.9-99.9, 99.9-100%.

(2) The vertical columns are situated midway between the numbers in the top line to indicate that data in each column apply to a class of particle that is defined by the numbers on each side of the column.

(3) The value of the data numbers refer to proportions (out of 100) of unliberated mineral at each point.

(4) The left vertical column gives the sizes in micrometers of unliberated grains which occur in the particles, i.e. 3.25, 4.60, 6.50, 9.19, 13.0, 18.4, 26.0, 36.8, 52.0, 73.5, 104, 147 and 208.

(5) The horizontal data lines are situated between numbers that designate grain sizes to indicate that the data in each horizontal line apply to grains whose size is within the size range defined the numbers above and below the horizontal line.

(6) Each horizontal line gives the classification for particles that contain unliberated grains which have a specific size range.

(7) Each vertical column gives the size distribution of unliberated grains that occur in one class of particles.

(8) The bottom data line is the sum for grains of all sizes. It is, therefore, the classification of particles without regard to sizes of the unliberated grains in the particles. This line was used to plot particle classification histograms.

(9) The right column is the sum for grains that occur in particles of all classes. Therefore, it is the size distribution of the unliberated grains without regard to class of host particle. This column was used to plot the grain size distribution histograms.

(10) The matrix of the table was used to plot the 3D diagram. It is noteworthy that the 3D diagrams are laid out in the same manner as the matrix of the tables, with the height of the vertical line in the diagrams being proportional to the value of the data in the tables.

GENERAL CAPTION FOR FIGURES 2 TO 5

Diagrams for Unliberated Grains

The left diagrams give the classification of particles, the middle diagrams the size distributions, and the right diagrams are 3D diagrams that show the relative proportions of mineral grains of a specific size occurring in particular classes of particles. Phase % = class of particle, and dia (mic) = diameter of grain in micrometres. The Z-axes of 3D diagrams give the relative vol % of unliberated mineral.

D1 - B5

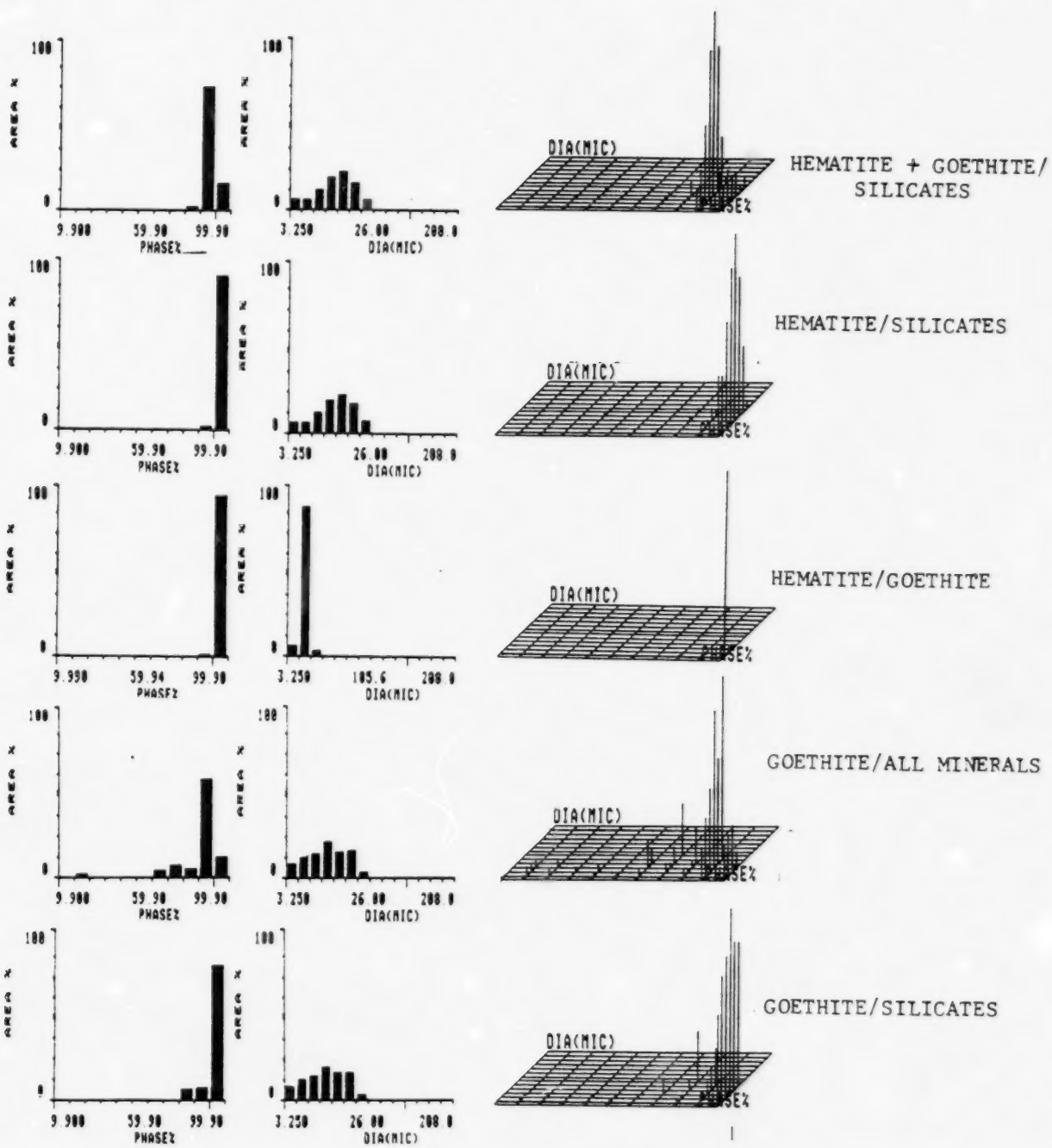

Fig. 1. Classification of particles in Sample D1-B5.

D1 - B5

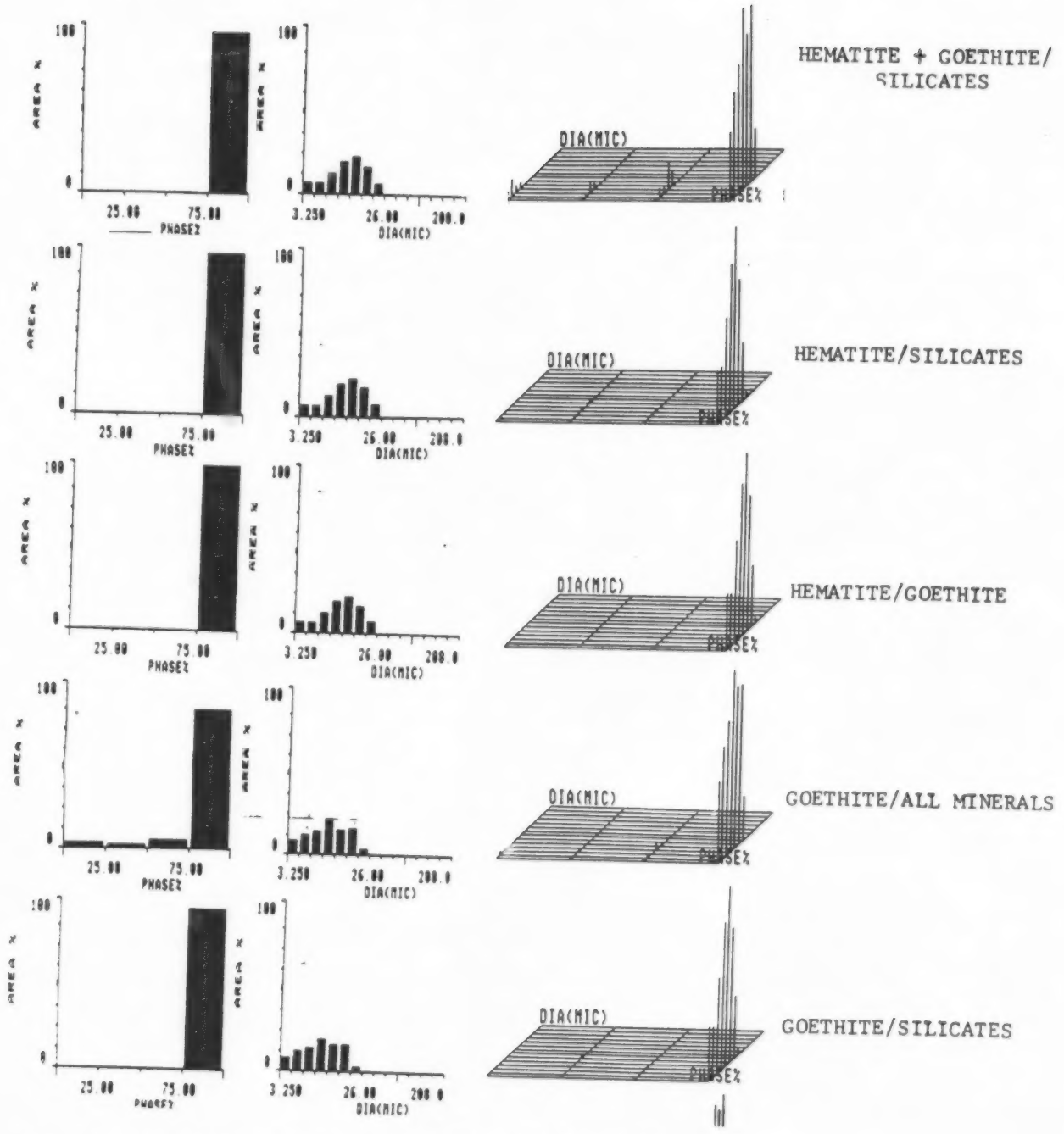

Fig. 2. Classification of particles in Sample D1-B5.

D3 - B8

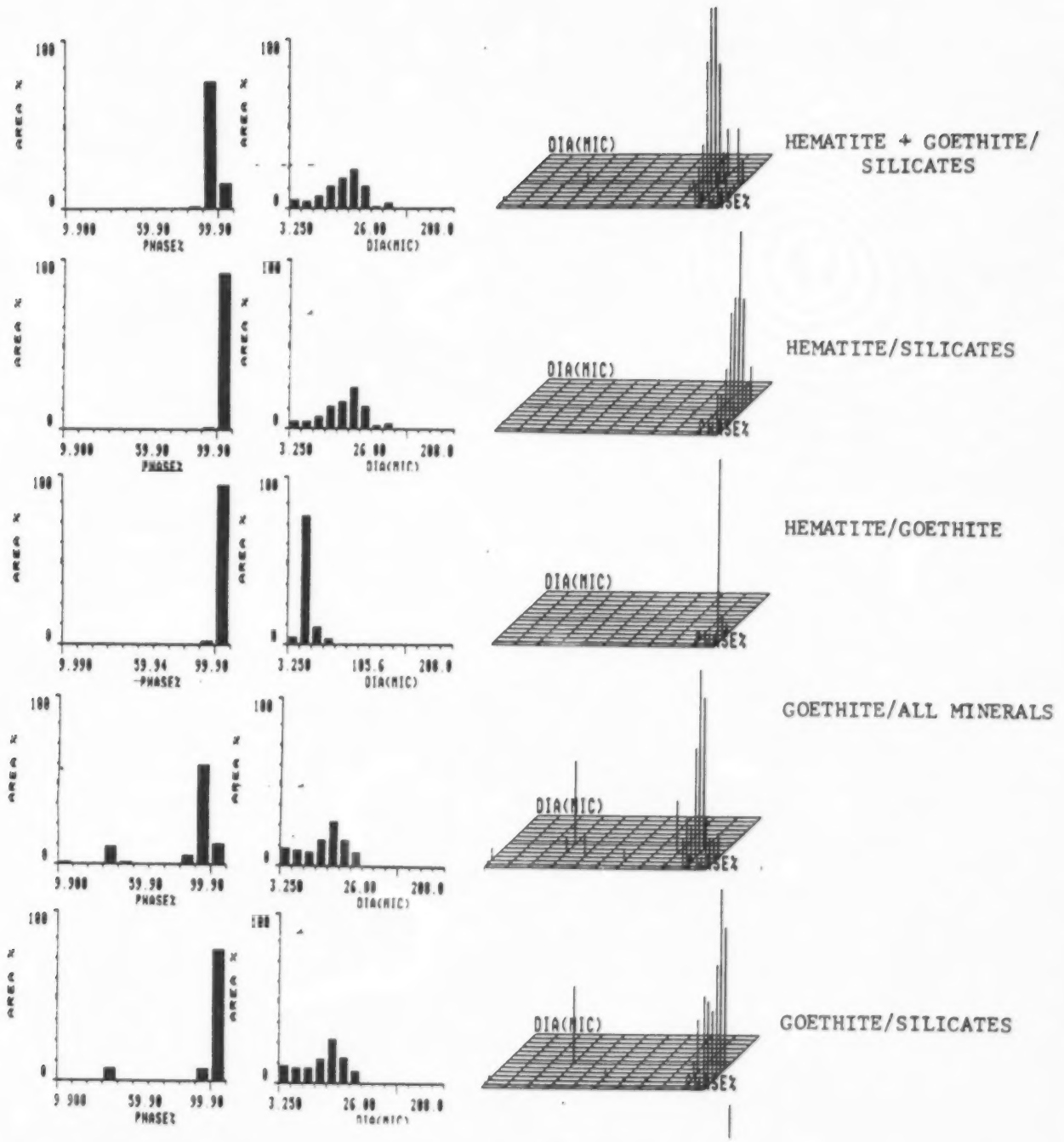

Fig. 3. Classification of particles in Sample D3-B8.

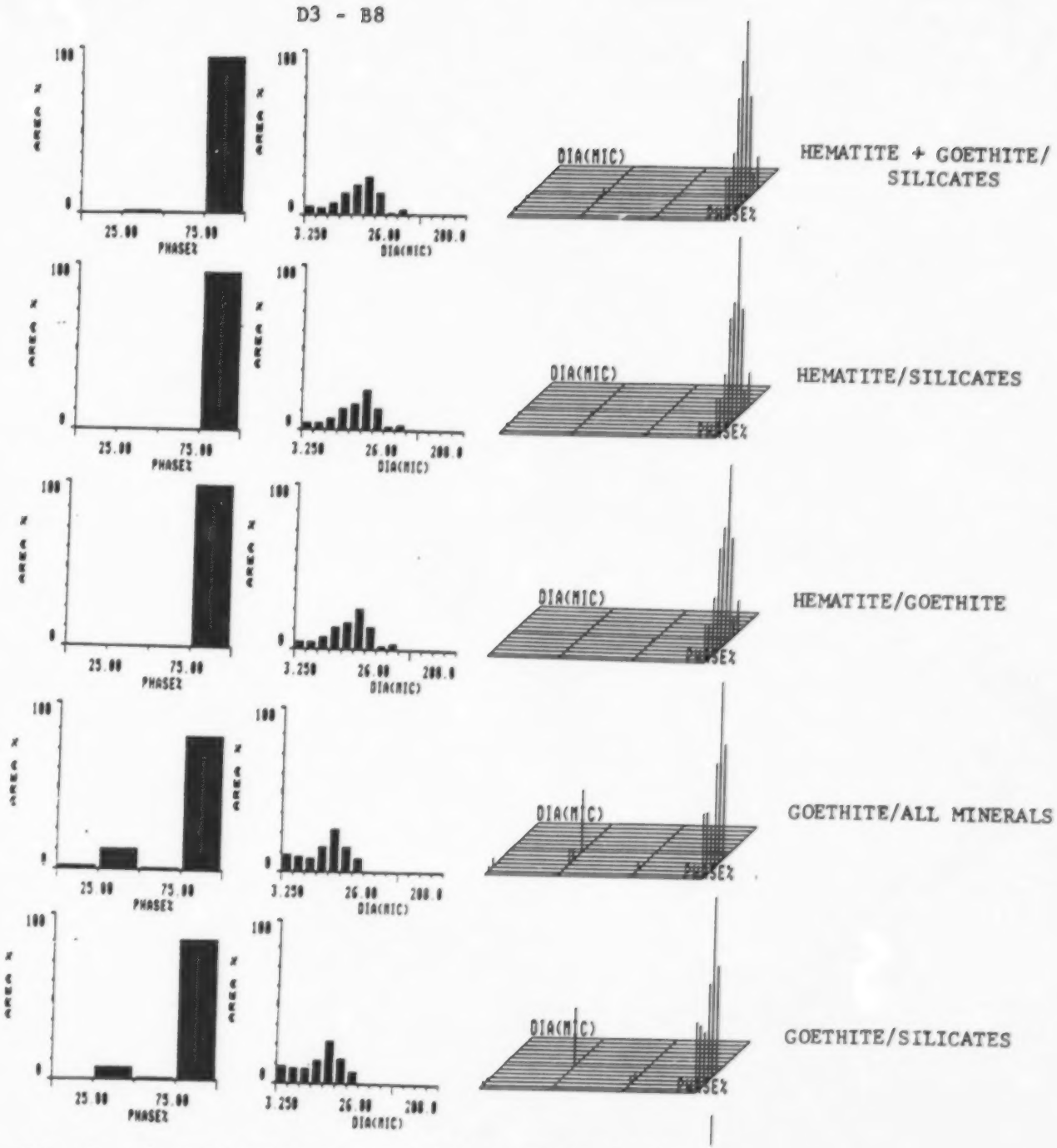

Fig. 4. Classification of particles in Sample D3-B8.

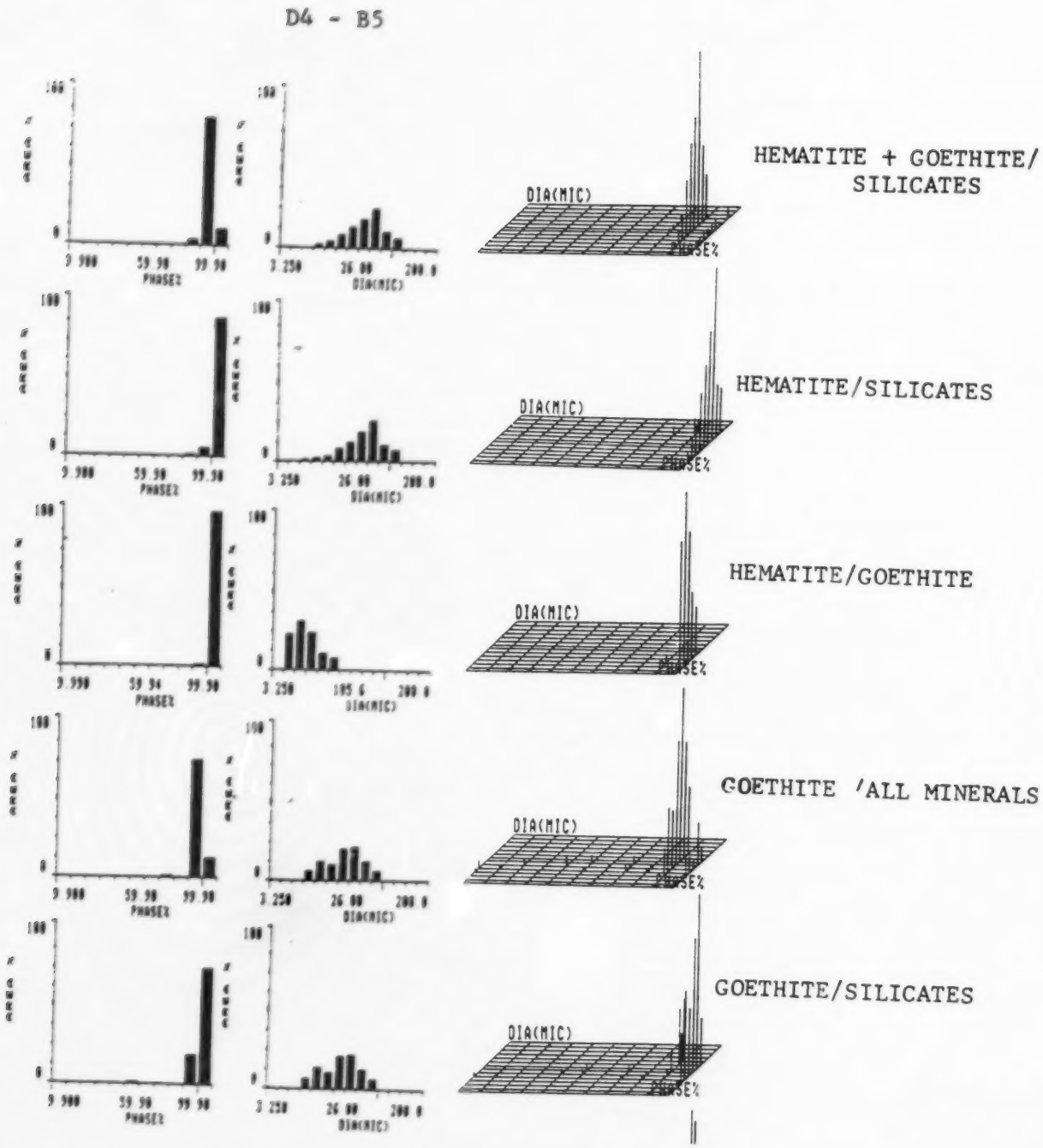

Fig. 5. Classification of particles in Sample D4-B5.

D4 - B5

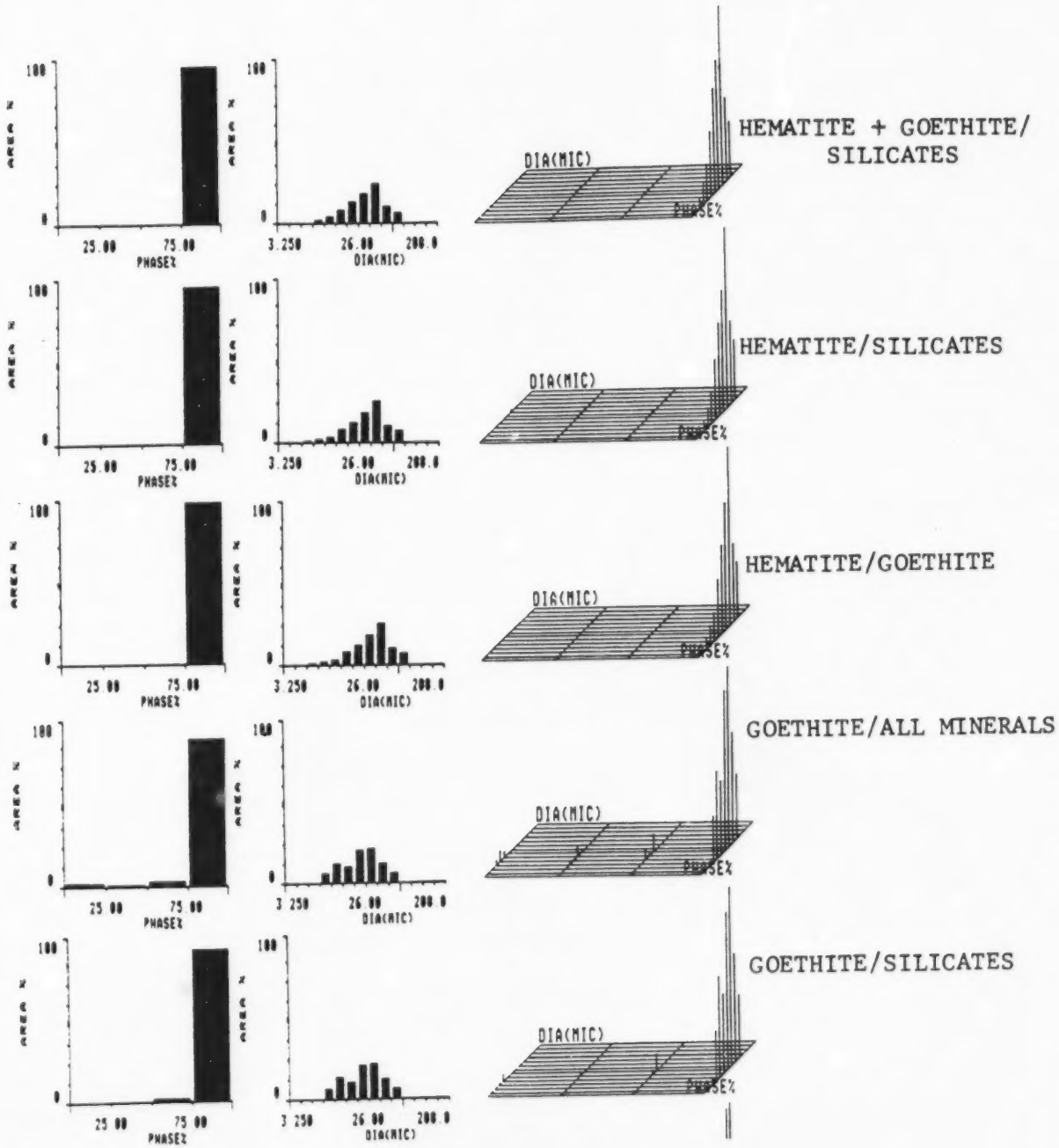

Fig. 6. Classification of particles in Sample D4-B5.

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9	
	.205	.328E-01	.207E-01	.392E-01	.289E-01	.236E-01	.355E-01	.184E-01	.129	2.75	4.38	7.58
3.25												
	.860E-01	.826E-01	.157E-01	0.00	.439E-01	.461E-01	.417E-01	.588E-01	.241	4.31	2.76	7.69
4.60												
	.151	.948E-01	.320E-01	.496E-01	.153	.527E-01	.203	.183	.436	8.61	3.98	13.9
6.58												
	.143	0.00	0.00	.403	.939E-01	0.00	.202	.544	.598	16.1	2.84	20.9
9.19												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.432	1.68	19.7	2.18	23.9
13.0												
	0.00	0.00	0.00	0.00	.442	0.00	.304	.267	0.00	15.6	.689	17.3
18.4												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.496	.502	5.54	1.19	7.73
26.0												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02	0.00	1.02
36.8												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52.0												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73.5												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104.												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	.384	.210	.685E-01	.492	.761	.122	.786	1.99	3.59	73.6	17.8	100.

DEF 064 D1-B5 O.C.M. 512*512

table 0 8 SUMS
variable z: AREA x
variable x: PHASEx
variable y: DIA(MIC)

	25.0	50.0	75.0		
	.246	.798E-01	.696E-01	7.18	7.58
3.25					
	.184	.439E-01	.107	7.35	7.69
4.60					
	.278	.202	.256	13.1	13.9
6.58					
	.143	.497	.577	19.7	20.9
9.19					
	0.00	0.00	0.00	23.9	23.9
13.0					
	0.00	.442	.304	16.6	17.3
18.4					
	0.00	0.00	0.00	7.73	7.73
26.0					
	0.00	0.00	0.00	1.02	1.02
36.8					
	0.00	0.00	0.00	0.00	0.00
52.0					
	0.00	0.00	0.00	0.00	0.00
73.5					
	0.00	0.00	0.00	0.00	0.00
104.					
	0.00	0.00	0.00	0.00	0.00
147.					
	0.00	0.00	0.00	0.00	0.00
208.					
	0.00	0.00	0.00	0.00	0.00
	.851	1.26	1.31	96.6	100.

table # 3 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.98	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9	
3.25	.771	.542	.323	0.00	.250	.128	.161	0.00	.360	3.24	3.31	9.09
4.60	.159	.995	.845	0.00	.351	.254	.866	.175	.783	5.60	3.94	14.0
6.50	0.00	.776	0.00	.601	.792	0.00	0.00	.962	.486	7.88	4.47	16.2
9.19	0.00	.738	.703	0.00	0.00	0.00	2.76	.635	.897	14.6	1.74	22.1
13.0	0.00	0.00	0.00	0.00	0.00	0.00	1.57	1.66	3.49	9.90	0.00	16.6
18.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.3	0.00	17.3
26.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.95	0.00	0.00	0.00	4.95
36.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	.929	3.05	1.87	.601	1.39	.382	5.36	8.39	6.01	58.5	13.5	100.0

table # 9 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	1.44	.449	.289	6.91	9.09
4.60	1.84	.589	1.12	10.5	14.0
6.50	.776	1.39	.962	12.8	16.0
9.19	.738	.703	2.76	17.9	22.1
13.0	0.00	0.00	1.57	15.0	16.6
18.4	0.00	0.00	0.00	17.3	17.3
26.0	0.00	0.00	0.00	4.95	4.95
36.8	0.00	0.00	0.00	0.00	0.00
52.0	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	4.79	3.05	6.70	85.4	100.

table # 4 SUMS
variable z: AREA x
variable x: PHASEx
variable y: DIA(MIC)

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9		
3.25	.209	.215E-01	.301E-01	.450E-01	.231E-01	.372E-01	.311E-01	.120E-01	0.00	.465E-01	7.27	7.72
4.60	.818E-01	.532E-01	.181E-01	0.00	.303E-01	.238E-01	.322E-01	.473E-01	0.00	.161	6.79	7.24
6.50	.179	.682E-01	.368E-01	.570E-01	.132	.606E-01	.101	.239	.104	.163	12.5	13.6
9.19	.164	0.00	0.00	.237	0.00	.113	.232	.312	0.00	.796	18.3	20.2
13.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.421	1.29	21.9	23.6
18.4	0.00	0.00	0.00	0.00	.508	0.00	0.00	.306	0.00	1.04	16.3	18.1
26.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.376	0.00	7.74	8.32
36.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	1.17
52.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	.634	.135	.858E-01	.339	.693	.234	.396	.917	1.10	3.49	92.0	100.

DEF @64 D1-B5 Q.C.M. 512*512

table # 10 SUMS
variable z: AREA x
variable x: PHASEx
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	.234	.951E-01	.684E-01	7.33	7.72
4.60	.153	.303E-01	.778E-01	6.98	7.24
6.50	.276	.189	.295	12.9	13.6
9.19	.164	.237	.477	19.3	20.2
13.0	0.00	0.00	0.00	23.6	23.6
18.4	0.00	.508	0.00	17.6	18.1
26.0	0.00	0.00	0.00	8.32	8.32
36.8	0.00	0.00	0.00	1.17	1.17
52.0	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	.827	1.06	.918	97.2	100.

table # 5 SUMS
variable z: AREA %
variable x: PHASEx
variable y: DIA(MIC)

	9.98	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9	
3.25	.235	.103	0.00	0.00	0.00	0.00	.224	.125	0.00	.215	8.89	9.79
4.60	.160	.363	0.00	0.00	0.00	.431	.165	0.00	.391	0.00	12.1	13.6
6.50	0.00	.437	0.00	0.00	.376	0.00	0.00	0.00	.442	.613	13.7	15.6
9.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.64	0.00	1.42	17.8	20.9
13.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	2.22	14.2	17.7
18.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.67	13.8	17.5
26.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.98	0.00	0.00	4.98
36.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	.395	.903	0.00	0.00	.376	.431	.389	1.76	7.09	8.14	80.5	100.0

DEF 064 D1-B5 Q.C.M. 512*512

table # 11 SUMS
variable z: AREA %
variable x: PHASEx
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	.338	0.00	.349	9.10	9.79
4.60	.523	0.00	.596	12.5	13.6
6.50	.437	.376	0.00	14.8	15.6
9.19	0.00	0.00	1.00	19.9	20.9
13.0	0.00	0.00	0.00	17.7	17.7
18.4	0.00	0.00	0.00	17.5	17.5
26.0	0.00	0.00	0.00	4.98	4.98
36.8	0.00	0.00	0.00	0.00	0.00
52.0	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	1.38	.376	1.95	96.4	100.0

table # 6 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.99	20.0	30.0	40.0	50.0	59.9	69.9	79.9	89.9	99.9	
3.25	.157E-01	0.00	.196E-01	.453E-02	.111E-01	.117E-01	0.00	0.00	.701E-02	.214E-01	7.56	7.65
20.3	0.00	.455E-01	.284E-01	.222	0.00	.194	.164	.414	1.24	1.51	84.5	88.3
37.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.748	3.30	4.05
54.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
106.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
123.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
140.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
157.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
174.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
191.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	.157E-01	.455E-01	.480E-01	.227	.111E-01	.286	.164	.414	1.25	2.28	95.3	100.0

DEF 064 D1-B5 D.C.M. 512*512

table # 12 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	.157E-01	.352E-01	.117E-01	7.59	7.65
4.60	0.00	.381E-01	.108	7.07	7.21
6.50	.455E-01	.406E-01	.902E-01	13.4	13.6
9.19	0.00	.164	.962E-01	20.3	20.6
13.0	0.00	0.00	.164	23.7	23.9
18.4	0.00	0.00	0.00	17.8	17.8
26.0	0.00	0.00	0.00	8.14	8.14
36.8	0.00	0.00	0.00	1.15	1.15
52.0	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	.612E-01	.278	.478	99.2	100.

variable x: PHASE%
variable y: DIA(MIC)

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9		
3.25	.112	.550E-01	.185E-01	0.00	.212E-01	0.00	.221E-01	0.00	.622E-01	2.35	3.37	6.01
4.60	.247	.371E-01	0.00	.412E-01	.305E-01	0.00	.457E-01	.341E-01	.144	3.69	1.61	5.88
6.50	.488	.577E-01	0.00	.729E-01	.135	0.00	.134	0.00	.141	5.22	2.64	8.89
9.19	0.00	0.00	0.00	0.00	.106	.164	0.00	.319	.619	12.5	.960	14.7
13.0	.235	0.00	0.00	.286	0.00	0.00	0.00	0.00	.672	17.1	.798	19.1
18.4	0.00	0.00	.436	.502	0.00	0.00	0.00	0.00	.920	16.8	5.56	24.3
26.0	0.00	0.00	0.00	1.01	0.00	0.00	0.00	0.00	0.00	11.2	1.84	14.0
36.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.71	0.00	2.71
52.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.39	0.00	4.39
73.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.00	.150	.454	1.91	.293	.164	.202	.354	2.56	76.1	16.8	100.

DEF 064 D3-B8 Q.C.M. 512*512

table 6 8 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	.167	.394E-01	.221E-01	5.79	6.01
4.60	.284	.717E-01	.457E-01	5.48	5.88
6.50	.546	.288	.134	8.00	8.89
9.19	0.00	.106	.164	14.4	14.7
13.0	.235	.286	0.00	18.6	19.1
18.4	.436	.502	0.00	23.3	24.3
26.0	0.00	1.01	0.00	13.0	14.0
36.8	0.00	0.00	0.00	2.71	2.71
52.0	0.00	0.00	0.00	4.39	4.39
73.5	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	1.67	2.22	.366	95.7	100.0

table # 3 SUMS
variable z: AREA %
variable x: PHASEx
variable y: DIA(MIC)

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9	
3.25	.362	.185	.158	.187	.356	.150	.367	0.00	.163	3.42	5.65	11.2
4.60	.415	.415	0.00	0.00	0.00	.335	0.00	0.00	.567	5.44	3.00	10.2
6.50	1.52	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	4.23	2.33	9.28
9.19	0.00	0.00	0.00	0.00	2.06	0.00	0.00	0.00	0.00	11.9	2.86	16.8
13.0	0.00	0.00	0.00	1.80	0.00	0.00	0.00	0.00	5.77	19.7	0.00	27.3
18.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.2	0.00	16.2
26.0	0.00	0.00	0.00	9.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.02
36.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.50	.600	.158	11.0	2.42	.484	1.57	0.00	6.50	60.9	13.8	100.

DEF 064 D3-B8 Q.C.M. 512*512

table # 9 SUMS
variable z: AREA %
variable x: PHASEx
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	.905	.543	.517	9.23	11.2
4.60	.830	0.00	.335	9.00	10.2
6.50	1.52	0.00	1.20	6.56	9.28
9.19	0.00	2.06	0.00	14.8	16.8
13.0	0.00	1.80	0.00	25.5	27.3
18.4	0.00	0.00	0.00	16.2	16.2
26.0	0.00	9.02	0.00	0.00	9.02
36.8	0.00	0.00	0.00	0.00	0.00
52.0	0.00	0.00	0.00	0.00	0.00
73.5	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	3.26	13.4	2.05	81.3	100.0

table # 4 SUMB
variable z: AREA %
variable x: PHASEx
variable y: DIA(MIC)

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9		
3.25	.124	.384E-01	.207E-01	0.00	.237E-01	0.00	0.00	0.00	0.00	.961E-01	5.40	5.70
4.60	.230	.444E-01	0.00	.514E-01	.340E-01	0.00	.510E-01	0.00	0.00	.152	4.80	5.36
6.50	.469	.644E-01	0.00	0.00	.151	0.00	0.00	0.00	.564E-01	.177	7.66	8.57
9.19	0.00	0.00	0.00	0.00	.118	0.00	0.00	.113	.122	.340	14.3	15.0
13.0	.262	0.00	0.00	.319	0.00	0.00	0.00	0.00	0.00	.762	15.8	17.1
18.4	0.00	0.00	.499	.561	0.00	0.00	0.00	0.00	.536	.615	23.6	25.9
26.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.5	14.5
36.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.03	3.03
52.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	4.90
73.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.89	.147	.520	.932	.327	0.00	.510E-01	.113	.715	2.14	94.0	100.0

DEF 064 D3-B8 Q.C.M. 512*512

table # 10 SUMB
variable z: AREA %
variable x: PHASEx
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	.163	.440E-01	0.00	5.49	5.70
4.60	.275	.854E-01	.510E-01	4.95	5.36
6.50	.533	.151	0.00	7.89	8.57
9.19	0.00	.118	0.00	14.9	15.0
13.0	.262	.319	0.00	16.5	17.1
18.4	.499	.561	0.00	24.8	25.9
26.0	0.00	0.00	0.00	14.5	14.5
36.8	0.00	0.00	0.00	3.03	3.03
52.0	0.00	0.00	0.00	4.90	4.90
73.5	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	1.73	1.28	.510E-01	96.9	100.0

table # 5 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9		
.266E-02	.184	0.00	0.00	0.00	0.00	.197	.170	0.00	0.00	10.7	11.	3.25
.413	0.00	.482	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.67	10.	4.60
.660	0.00	0.00	0.00	0.00	0.00	.348	.644	0.00	0.00	8.18	10.	6.50
0.00	0.00	0.00	0.00	0.00	1.11	0.00	0.00	0.00	1.94	12.9	15.	9.19
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.15	21.0	27.	13.0
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.1	16.	18.4
0.00	0.00	0.00	8.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.9	26.0
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	36.8
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	52.0
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	73.5
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	104.
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	147.
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	208.
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
1.00	.184	.482	8.97	0.00	1.11	.745	.814	0.00	8.09	78.6	100.	

DEF 064 D3-B8 Q.C.M. 512*512

D3-B8

table # 11 SUMB
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0		
.186	0.00	.367	10.7	11.3	3.25
.814	0.00	0.00	9.67	10.5	4.60
.660	0.00	1.19	8.18	10.0	6.50
0.00	0.00	1.11	14.8	15.9	9.19
0.00	0.00	0.00	27.2	27.2	13.0
0.00	0.00	0.00	16.1	16.1	18.4
0.00	8.97	0.00	0.00	8.97	26.0
0.00	0.00	0.00	0.00	0.00	36.8
0.00	0.00	0.00	0.00	0.00	52.0
0.00	0.00	0.00	0.00	0.00	73.5
0.00	0.00	0.00	0.00	0.00	104.
0.00	0.00	0.00	0.00	0.00	147.
0.00	0.00	0.00	0.00	0.00	208.
0.00	0.00	0.00	0.00	0.00	
1.66	8.97	2.67	86.7	100.	

table # 6 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.99	20.0	30.0	40.0	50.0	59.9	69.9	79.9	89.9	99.9		
3.25	0.00	0.00	0.00	.350E-01	.551E-01	0.00	0.00	0.00	0.00	0.00	5.61	5.70
20.3	.310E-01	0.00	.564E-01	.297E-01	0.00	.144	.498	.731E-01	0.00	2.29	74.6	77.7
37.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	10.5	11.7
54.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	4.90
71.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
106.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
123.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
140.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
157.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
174.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
191.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	.310E-01	0.00	.564E-01	.647E-01	.551E-01	.144	.498	.731E-01	0.00	3.48	95.6	100.

DEF 064 D3-B8 Q.C.M. 512*512

table # 12 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	0.00	.901E-01	0.00	5.61	5.70
4.68	.310E-01	.297E-01	.357E-01	5.23	5.33
6.50	0.00	.564E-01	0.00	8.55	8.60
9.19	0.00	0.00	.144	14.8	15.0
13.0	0.00	0.00	0.00	17.1	17.1
18.4	0.00	0.00	.462	25.4	25.9
26.0	0.00	0.00	0.00	14.5	14.5
36.8	0.00	0.00	0.00	3.03	3.03
52.0	0.00	0.00	0.00	4.90	4.90
73.5	0.00	0.00	0.00	0.00	0.00
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	.310E-01	.176	.642	99.2	100.

DEF 064 D4-85 Q.C.M. 512*512

table # 2 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9		
.423E-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.619E-02	.853E-01	.957E-	
3.25												
.488E-02	0.00	0.00	0.00	.619E-02	0.00	0.00	0.00	.117E-01	.528E-01	.344	.419	
4.60												
.270E-01	0.00	0.00	0.00	.117E-01	0.00	0.00	0.00	.860E-01	.607	1.19	1.92	
6.50												
.700E-01	.580E-01	0.00	.381E-01	0.00	.264E-01	0.00	0.00	.840E-01	2.10	1.28	3.66	
9.19												
.190	.495E-01	0.00	0.00	.544E-01	.687E-01	0.00	.752E-01	.209	3.67	1.39	5.71	
13.0												
0.00	0.00	0.00	.847E-01	.181	0.00	0.00	.129	.954E-01	7.62	1.31	9.43	
18.4												
0.00	0.00	0.00	0.00	.137	.143	0.00	.127	.818	11.9	1.62	14.8	
26.0												
0.00	.259	0.00	.349	.242	.662	0.00	0.00	1.01	15.1	1.60	19.3	
36.8												
0.00	.466	.449	0.00	0.00	0.00	0.00	0.00	.525	23.3	.782	25.5	
52.0												
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	10.3	0.00	11.5	
73.5												
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.93	1.78	7.71	
104.												
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
147.												
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
208.												
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
.296	.833	.449	.472	.633	.900	0.00	.331	4.08	80.6	11.4	100.0	

DEF 064 D4-85 Q.C.M. 512*512

table # 8 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0	.	
.423E-02	0.00	0.00	.913E-01	.957E-01	
3.25					
.488E-02	.619E-02	0.00	.408	.419	
4.60					
.270E-01	.117E-01	0.00	1.88	1.92	
6.50					
.128	.381E-01	.264E-01	3.46	3.66	
9.19					
.239	.544E-01	.144	5.27	5.71	
13.0					
0.00	.266	.736E-01	9.09	9.43	
18.4					
0.00	.137	.278	14.4	14.8	
26.0					
.259	.591	.662	17.8	19.3	
36.8					
.466	.449	0.00	24.6	25.5	
52.0					
0.00	0.00	0.00	11.5	11.5	
73.5					
0.00	0.00	0.00	7.71	7.71	
104.					
0.00	0.00	0.00	0.00	0.00	
147.					
0.00	0.00	0.00	0.00	0.00	
208.					
0.00	0.00	0.00	0.00	0.00	
1.13	1.55	1.18	96.1	100.0	

DEF 064 D4-85 Q.C.M. 512*512

table # 3 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.98	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9		
.356E-01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.274E-01	.192	.255	
3.25												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.384E-01	.439E-01	.822E-	
4.60												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.175	.737	.913	
6.58												
	.378	.268	.164	.447	0.00	0.00	0.00	0.00	.197	3.47	2.26	7.38
9.19												
	1.09	.417	0.00	0.00	.266	.578	.233	1.04	.543	7.65	2.12	13.9
13.0												
	0.00	0.00	.858	0.00	1.53	0.00	.521	.466	.474	6.89	1.21	11.9
18.4												
	0.00	0.00	0.00	0.00	0.00	1.28	0.00	1.07	0.00	14.4	5.16	21.8
26.0												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.2	2.01	22.2
36.8												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.6	0.00	13.6
52.0												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.96	0.00	7.96
73.5												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104.												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.												
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.70	.677	1.01	.447	1.79	1.77	.754	2.57	1.21	74.3	13.7	100.

DEF 064 D4-85 Q.C.M. 512*512

table # 9 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0	
.356E-01	0.00	0.00	.219	.255
3.25				
	0.00	0.00	.822E-01	.822E-01
4.60				
	0.00	0.00	.913	.913
6.58				
	.839	.611	5.93	7.38
9.19				
	1.51	.266	1.44	10.7	13.9
13.0				
	.858	1.53	.521	9.04	11.9
18.4				
	0.00	0.00	2.27	19.6	21.8
26.0				
	0.00	0.00	0.00	22.2	22.2
36.8				
	0.00	0.00	0.00	13.6	13.6
52.0				
	0.00	0.00	0.00	7.96	7.96
73.5				
	0.00	0.00	0.00	0.00	0.00
104.				
	0.00	0.00	0.00	0.00	0.00
147.				
	0.00	0.00	0.00	0.00	0.00
208.				
	0.00	0.00	0.00	0.00	0.00
	3.23	2.48	4.23	90.1	100.0

DEF 064 D4-85 Q.C.M. 512*512

table # 4 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9	
.293E-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.524E-01	.554E-	3.25
.558E-02	0.00	0.00	0.00	.697E-02	0.00	0.00	0.00	.132E-01	0.00	.460	.485	4.60
.487E-01	0.00	0.00	0.00	.132E-01	0.00	0.00	0.00	0.00	.231E-01	1.98	2.06	6.50
.414E-01	.466E-01	0.00	0.00	0.00	.297E-01	0.00	0.00	0.00	.458E-01	3.13	3.29	9.19
.107	0.00	0.00	0.00	.612E-01	.356E-01	0.00	0.00	0.00	.359E-01	4.60	4.84	13.0
0.00	0.00	0.00	.953E-01	0.00	0.00	0.00	.829E-01	0.00	.151	8.72	9.05	18.4
0.00	0.00	0.00	0.00	.154	0.00	0.00	0.00	.453	.672	12.2	13.5	26.0
0.00	.291	0.00	.393	.273	.745	0.00	0.00	.395	.420	16.6	19.1	36.8
0.00	.525	.506	0.00	0.00	0.00	0.00	0.00	0.00	.511	25.4	26.9	52.0
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41	2.79	7.77	12.0	73.5
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01	6.70	8.71	104.
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	147.
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	208.
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
.197	.863	.506	.488	.389	.810	0.00	.829E-01	2.27	6.66	87.6	100.	

DEF 064 D4-85 Q.C.M. 512*512

table # 10 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0	
.293E-02	0.00	0.00	.524E-01	.554E-01	3.25
.558E-02	.697E-02	0.00	.473	.485	4.60
.487E-01	.132E-01	0.00	2.01	2.06	6.50
.888E-01	0.00	.297E-01	3.18	3.29	9.19
.107	.612E-01	.356E-01	4.64	4.84	13.0
0.00	.953E-01	.829E-01	8.87	9.05	18.4
0.00	.154	0.00	13.3	13.5	26.0
.291	.665	.745	17.4	19.1	36.8
.525	.506	0.00	25.9	26.9	52.0
0.00	0.00	0.00	12.0	12.0	73.5
0.00	0.00	0.00	8.71	8.71	104.
0.00	0.00	0.00	0.00	0.00	147.
0.00	0.00	0.00	0.00	0.00	208.
0.00	0.00	0.00	0.00	0.00	
1.06	1.50	.893	96.5	100.	

table # 3 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.90	19.9	29.9	39.9	49.9	59.9	69.9	79.9	89.9	99.9		
3.25	.136E-01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.232	.246
4.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.819E-01	.819E-0
6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
9.19	.295	.139	0.00	.282	.117	0.00	0.00	.145	0.00	0.00	6.56	7.46
13.0	.729	.415	0.00	0.00	0.00	.311	0.00	.631	.333	.409	11.4	14.2
18.4	0.00	0.00	0.00	0.00	.786	.734	0.00	0.00	.464	.835	8.77	11.6
26.0	0.00	0.00	0.00	0.00	0.00	1.20	0.00	1.06	0.00	2.61	16.9	21.8
36.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.2	22.2
52.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.35	6.14	13.5
73.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.93	0.00	7.93
104.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.04	.554	0.00	.282	.903	2.24	0.00	1.84	.797	19.1	73.3	100.

DEF 864 D4-85 Q.C.M. 512*512

table # 11 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0		
3.25	.136E-01	0.00	0.00	.232	.246
4.60	0.00	0.00	0.00	.819E-01	.819E-01
6.50	0.00	0.00	0.00	1.00	1.00
9.19	.434	.319	.145	6.56	7.46
13.0	1.14	0.00	.311	12.8	14.2
18.4	0.00	.786	.734	10.1	11.6
26.0	0.00	0.00	2.26	19.5	21.8
36.8	0.00	0.00	0.00	22.2	22.2
52.0	0.00	0.00	0.00	13.5	13.5
73.5	0.00	0.00	0.00	7.93	7.93
104.	0.00	0.00	0.00	0.00	0.00
147.	0.00	0.00	0.00	0.00	0.00
208.	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	1.59	1.11	3.45	93.9	100.

table # 6 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	9.99	20.0	30.0	40.0	50.0	59.9	69.9	79.9	89.9	99.9	
.147E-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.506E-01	.521E-01
3.25											
.697E-02	.161E-01	.103E-01	.598E-01	0.00	.359E-01	.891E-01	0.00	.133	.167	22.7	23.2
20.3											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	.370	0.00	.575	30.7	31.7
37.4											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.38	23.0	24.4
54.4											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.0	12.0
71.5											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.71	8.71
88.6											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
106.											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
123.											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
140.											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
157.											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
174.											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
191.											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
208.											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
.843E-02	.161E-01	.103E-01	.598E-01	0.00	.359E-01	.891E-01	.370	.133	2.12	97.2	100.0

DEF 064 D4-B5 Q.C.M. 512*512

table # 12 SUMS
variable z: AREA %
variable x: PHASE%
variable y: DIA(MIC)

	25.0	50.0	75.0	
.147E-02	0.00	0.00	.506E-01	.521E-01
3.25				
.147E-01	0.00	0.00	.479	.493
4.60				
.187E-01	0.00	0.00	2.03	2.05
6.58				
0.00	.213E-01	0.00	3.25	3.27
9.19				
0.00	.385E-01	.125	4.63	4.80
13.0				
0.00	0.00	0.00	9.05	9.05
18.4				
0.00	0.00	0.00	13.5	13.5
26.0				
0.00	0.00	0.00	19.2	19.2
36.8				
0.00	0.00	0.00	26.9	26.9
52.0				
0.00	0.00	0.00	12.0	12.0
73.5				
0.00	0.00	0.00	8.71	8.71
104.				
0.00	0.00	0.00	0.00	0.00
147.				
0.00	0.00	0.00	0.00	0.00
208.				
0.00	0.00	0.00	0.00	0.00
.348E-01	.598E-01	.125	99.8	100.0

APPENDIX B

ANALYTICAL RESULT OF FACTORAIL DESIGN WITH FADESN PROGRAM

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***************FACTORIAL DESIGN***************

HERE IS A LIST OF EXPERIMENTAL DESIGNS AVAILABLE IN
THIS PROGRAM :

                                    DESIGN MATRIX                  POSSIBLE
DESIGN NO.   NO. OF LEVELS   DIMENSIONS (ROW X COLUMN)   NO. OF FACTORS
----------   -------------   ---------------------------   --------------
    1              2                  4  X  3                2 OR 3
    2              2                  8  X  7                3,4,5,6 OR 7
    3              2                  16 X 15                4,5,6,7 OR 8
    4              3                  9  X  4                2,3 OR 4
    5              4                  16 X  5                2,3,4 OR 5

WHICH DESIGN YOU WANT (1,2,...OR 5,0 IF NONE OF THESE)?
2
WANT TO EXAMINE THE MATRIX (Y/N)?
Y

DESIGN NO.      DESIGN MATRIX
----------      -------------
    2.
                -1  -1   1  -1   1   1  -1
                 1  -1  -1  -1  -1   1   1
                -1   1  -1  -1   1  -1   1
                 1   1   1  -1  -1  -1  -1
                -1  -1   1   1  -1  -1   1
                 1  -1  -1   1   1  -1  -1
                -1   1  -1   1  -1   1  -1
                 1   1   1   1   1   1   1

IS THIS THE DESIGN YOU WANT (Y/N) ?
Y

INPUT  8 TEST RESULTS:
162 480 370 180 420 263 290 172

ANY REPEAT MEASUREMENTS (Y/N) ?
Y
ENTER THE NUMBER OF NO. 1 REPEAT MEASUREMENT (ENTER 0 TO FINISH):
3
ENTER THE TEST RESULTS FROM THIS REPEAT:
155 150 215
ENTER THE NUMBER OF NO. 2 REPEAT MEASUREMENT (ENTER 0 TO FINISH):
0

THE VARIANCE OF EXPERIMENTAL ERROR =  1308.3330
THE NUMBER OF DEGREES OF FREEDOM   =        2

WHICH CONFIDENCE LIMIT 90 OR 95 ?
95
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REGRESSION COEFF.		SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	CRITICAL F(1. 2) 18.513 @95. %C.L. F-RATIO	SIGNIFICANCE
B 0:	294.625	694431.100				
B 1:	-20.875	3486.125	1	3486.125	.2665E+01	NO
B 2:	-41.625	13861.130	1	13861.130	.1059E+02	NO
B 3:	-56.125	25200.130	1	25200.130	.1926E+02	YES
B 4:	-8.375	561.125	1	561.125	.4289E+00	NO
B 5:	-47.875	18336.130	1	18336.130	.1401E+02	NO
B 6:	-13.625	1485.125	1	1485.125	.1135E+01	NO
B 7:	65.875	34716.130	1	34716.130	.2653E+02	YES

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WANT TO EXIT THE PROGRAM (Y/N) ?
N
WHICH DESIGN YOU WANT (1,2,...OR 5,0 IF NONE OF THESE)?
2
WANT TO EXAMINE THE MATRIX (Y/N)?
N

INPUT  8 TEST RESULTS:
1.2 13.8 11.3 32.5 12.6 33.3 20.5 36.43

ANY REPEAT MEASUREMENTS (Y/N) ?
Y
ENTER THE NUMBER OF NO. 1 REPEAT MEASUREMENT (ENTER 0 TO FINISH):
3
ENTER THE TEST RESULTS FROM THIS REPEAT:
33.2 43.3 32.8
ENTER THE NUMBER OF NO. 2 REPEAT MEASUREMENT (ENTER 0 TO FINISH):
0

THE VARIANCE OF EXPERIMENTAL ERROR =     35.4033
THE NUMBER OF DEGREES OF FREEDOM   =        2

WHICH CONFIDENCE LIMIT 90 OR 95 ?
95
```

REGRESSION COEFF.		SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F-RATIO	CRITICAL F(1. 2) 18.513 @95. %C.L. SIGNIFICANCE
B 0:	20.204	3265.532				
B 1:	8.804	620.048	1	620.048	.1751E+02	NO
B 2:	4.979	198.304	1	198.304	.5601E+01	NO
B 3:	.479	1.834	1	1.834	.5179E-01	NO
B 4:	3.504	242.330	1	242.330	.6845E+01	NO
B 5:	.354	1.001	1	1.001	.2828E-01	NO
B 6:	-2.221	39.472	1	39.472	.1115E+01	NO
B 7:	-1.671	22.345	1	22.345	.6311E+00	NO

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WANT TO EXIT THE PROGRAM (Y/N) ?
Y
Stop - Program terminated.
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